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THE CONSTRUCTION OF THE HEAVENS[1]

ALTHOUGH at the present time our minds are largely absorbed by the war, the meeting of the British Association in Manchester indicates that we consider it right to make our annual review of scientific progress. I shall therefore make no apology for choosing the same subject for my address as I should have chosen in other circumstances. It is a subject far removed from war, being an account of the manner in which astronomers have with telescopes and spectroscopes investigated the skies and the conclusions they have reached on what Herschel called "The Construction of the Heavens."

Our knowledge of the fixed stars, as they were called by the old astronomers, is of comparatively recent origin, and is derived from two sources: (1) the measurement of small changes in the positions of the stars in the sky, and (2) the analysis of the light received from them and the measurement of its amount. To this end the numerous instruments of a modern observatory have been devised. The desire to examine fainter objects, and still more the necessity of increasing the accuracy of observations, has brought about a continuous improvement in the range and accuracy of astronomical instruments. Methods which had been perfected for observations of a few stars have been extended so that they can be applied to a large number. For these reasons the progress of sidereal astronomy may seem to have gone on slowly for a time. The more rapid progress of recent years arises

[1] Address of the President of the Section of Mathematics and Astronomy at the Manchester meeting of the British Association for the Advancement of Science.

from the accumulation of data, for which we are indebted to generations of astronomers, and from the gradual increase in power and perfection of our instruments.

The first insight into the stars as a whole naturally came from the survey of their numbers and distribution; and Herschel, who constructed the first great telescopes, explored the heavens with untiring skill and energy, and speculated boldly on his observations, is justly regarded as the founder of sidereal astronomy. In his great paper "On the Construction of the Heavens," Herschel gives the rules by which he was guided, which I should like to quote, as they may well serve as a motto to all who are engaged in the observational sciences:

> But first let me mention that if we would hope to make any progress in an investigation of this delicate nature we ought to avoid two opposite extremes of which I can hardly say which is the most dangerous. If we indulge a fanciful imagination and build worlds of our own, we must not wonder at our going wide from the path of truth and nature; but these will vanish like the Cartesian vortices, that soon gave way when better theories were offered. On the other hand, if we add observation to observation, without attempting to draw not only certain conclusions but also conjectural views from them, we offend against the very end for which only observations ought to be made. I will endeavor to keep a proper medium; but if I should deviate from that I could wish not to fall into the latter error.

In this spirit he discussed the "star gauges" or counts of stars visible with his great reflector in different parts of the sky, and concluded from them that the stars form a cluster which stretches to an unknown but finite distance, considerably greater in the plane of the Milky Way than in the perpendicular direction. He gave this distance as 497 times that of Sirius. He did not hesitate to advance the theory that some of the nebulæ were similar clusters of stars, of which that in Andromeda, judging from its size, was the nearest. Herschel had no means of telling the scale of the sidereal system, though he probably supposed the parallax of Sirius to be of the order of 1″.

Though some of the assumptions made by Herschel are open to criticism, the result at which he arrived is correct in its general outline. I shall attempt to give a brief account of some of the principal methods used to obtain more definite knowledge of the extent and constitution of this "island universe." The stars of which most is known are, in general, those nearest to us. If the distance of a star has been measured, its coordinates, velocity perpendicular to the line of sight, and luminosity are easily found. In the case of a double star the orbit of which is known the mass may also be determined. But only a very small proportion of the stars are sufficiently near for the distance to be determinable with any accuracy. Taking the distance corresponding to a parallax of 1″ or the parsec as unit—*i. e.*, 200,000 times the distance of the earth from the sun—fairly accurate determinations can be made up to a distance of 25 parsecs, but only rough ones for greater distances.

For much greater distances average results are obtainable from proper motions, and the mean distances of particular classes of stars—for instance, stars of a given magnitude or given type of spectrum—can be found with confidence up to a distance of 500 parsecs, and with considerable uncertainty to twice this distance. The density of stars in space as a function of the distance, the percentage of stars within different limits of luminosity, the general trend of the movements of stars and their average velocities can also be found, within the same limits of distance.

For all distances, provided the star is sufficiently bright, its velocity to or from the earth can be measured. The general

consideration of these velocities supplies complementary data which can not be obtained from proper motions, and confirms other results obtained by their means. For distances greater than 1,000 parsecs our knowledge is generally very vague. We have to rely on what can be learned from the amount and color of the light of the stars, and from their numbers in different parts of the sky.

PARALLAX

Let us begin with the portion of space nearest to us, within which the parallaxes of stars are determinable. The successful determination of stellar parallax by Bessel, Struve and Henderson in 1838 was a landmark in sidereal astronomy. The distances of three separate stars were successfully measured, and for the first time the sounding line which astronomers had for centuries been throwing into space touched bottom. The employment of the heliometer which Bessel introduced was the main source of our knowledge of the distances of stars until the end of the nineteenth century, and resulted in fairly satisfactory determination of the parallaxes of nearly one hundred stars. For the part of space nearest to us this survey is sufficiently complete for us to infer the average distances of the stars from one another—2½ to 3 parsecs. The parallax determinations of double stars of known orbits lead to the result that the masses of stars have not a very great range, but lie between forty times and one tenth of the mass of the sun.

When the absolute luminosities of the stars the distances of which have been measured are calculated, it is found that, unlike the masses, they exhibit a very great range. For example, Sirius radiates forty-eight times as much light as the sun, and Groombridge thirty-four only one hundredth part. This does not represent anything like the complete range, and Canopus, for example, may be ten thousand times as luminous as the sun. But among the stars near the solar system, the absolute luminosity appears to vary with the type of spectrum. Thus Sirius, of type A, a blue hydrogen star, is forty-eight times as luminous as the sun; Procyon of type F_5—bluer than the sun, but not so blue as Sirius—ten times; α Centauri, which is nearly of solar type, is twice as luminous. 61 Cygni of type K_5—redder than the sun—one tenth as luminous; while the still redder star of type Ma, Gr 34, is only one hundredth as luminous. In the neighborhood of the solar system one third of the stars are more luminous and two thirds less luminous than the sun. The luminosity decreases as the type of spectrum changes from A to M, *i. e.*, from the blue stars to the red stars.

These three results as to the density in space, the mass, and the luminosity have been derived from a very small number of stars. They show the great value of accurate determinations of stellar parallax. So soon as the parallax is known, all the other observational data are immediately utilizable. At the commencement of the present century the parallaxes of perhaps eighty stars were known with tolerable accuracy. Happily the number is now rapidly increasing by the use of photographic methods. Within the last year or two, the parallaxes of nearly two hundred stars have been determined and published. This year a committee of the American Astronomical Society, under the presidency of Professor Schlesinger, has been formed to coordinate the work of six or seven American and one or two English observatories. The combined program contains 1,100 stars, of which 400 are being measured by more than one observatory. We may expect results at the rate of two hundred a year, and

may therefore hope for a rapid increase of our knowledge of the stars within our immediate neighborhood.

VELOCITIES IN THE LINE OF SIGHT

The determination of radial velocities was initiated by Huggins in the early 'sixties, but trustworthy results were not obtained until photographic methods were introduced by Vogel in 1890. Since that time further increase in accuracy has been made, and the velocity of a bright star with sharp lines is determinable (apart from a systematic error not wholly explained) with an accuracy of ¼ kilometer per second. As the average velocities of these stars are between 10 and 20 kilometers a second, the proportional accuracy is of a higher order than can be generally obtained in parallax determinations or in other data of sidereal astronomy. A number of observatories in the United States and Europe, as well as in South America, the Cape, and Canada, are engaged in this work. Especially at the Lick Observatory under Professor Campbell's direction, the combination of a large telescope, a well-designed spectroscope and excellent climatic conditions have been utilized to carry out a bold program. At that observatory, with an offshoot at Cerro San Christobal in Chile, for the observation of stars in the southern hemisphere, the velocities of 1,200 of the brightest stars in the sky have been determined. Among the results achieved is a determination of the direction and amount of the solar motion. The direction serves to confirm the results from proper motions, but the velocity is only obtainable accurately by this method. This quantity, which enters as a fundamental constant in nearly all researches dealing with proper motion, is given by Campbell at 19.5 kilometers per second, or 4.1 times the distance of the earth from the sun per annum, though there is some uncertainty arising from a systematic error of unknown origin.

The observations of radial velocities have shown within what limits the velocities of stars lie and have given a general idea of their distribution. The most important result, and one of a somewhat surprising character, is that the mean velocities of stars, the motion of the sun being abstracted, increase with the type of spectrum. Thus the stars of type B, the helium stars, the stars of the highest temperature, have average radial velocities of only 6.5 kilometers per second; the hydrogen stars of type A have average velocities of 11 kilometers per second; the solar stars of 15 kilometers per second; while for red stars of types K and M it has increased slightly more to 17 kilometers per second. Further, the few planetary nebulæ—*i. e.*, condensed nebulæ with bright line spectra—have average velocities of 25 kilometers per second. There can be no question of the substantial accuracy of these results, as they are closely confirmed by discussions of proper motions. They are, however, very difficult to understand. On the face of it, there does not seem any reason why stars of a high temperature should have specially high velocities. A suggestion has been thrown out by Dr. Halm that as the helium stars have greater masses, these results are in accordance with an equi-partition of energy. But the distances of stars apart is so great that it seems impossible that this could be brought about by their interaction. Professor Eddington suggests that the velocities may be an indication of the part of space at which the stars were formed (*e. g.*, stars of small mass in outlying portions), and represents the kinetic energy they have acquired in arriving at their present positions.

The stars the radial velocities of which have been determined are, generally speak-

ing, brighter than the fifth magnitude, Fainter stars are now being observed. At the Mount Wilson Observatory, Professor Adams has determined the velocities of stars of known parallaxes, as there are great advantages in obtaining complete data for stars where possible. Extension of line-of-sight determinations to fainter stars is sure to bring a harvest of useful results, and a number of great telescopes are engaged, and others will shortly join in this important work.

PROPER MOTIONS

As proper motions are determined by the comparison of the positions of stars at two different epochs, they get to be known with constantly increasing accuracy as the time interval increases. The stars visible to the naked eye in the northern hemisphere were accurately observed by Bradley in 1755. Many thousands of observations of faint stars down to about 9.0 m. were made in the first half of the nineteenth century. An extensive scheme of reobservation was carried out about 1875 under the auspices of the Astronomische Gesellschaft. A great deal of reobservation of stars brighter than the ninth magnitude has been made this century in connection with the photographic survey of the heavens. For the bright stars all available material has been utilized and their proper motions have been well determined, and for the fainter stars this is being gradually accomplished.

Proper motions differ widely and irregularly in amount and direction. Herschel observed a tendency of a few stars to move towards one point of the sky, and attributed this sign of regularity to a movement of the solar system in the opposite direction. But puzzling differences given by different methods remained unexplained until the difficulty was resolved by Professor Kapteyn in a paper read before this section of the British Association at its meeting in South Africa ten years ago. He showed that the proper motions had a general tendency towards two different points of the sky and not towards one only, as would be expected if the motions of the stars themselves were haphazard, but viewed from a point in rapid motion. He concluded from this that there was a general tendency of the stars to stream in two opposite directions. It is interesting to notice that this great discovery was made by a simple graphical examination of the proper motions of stars in different regions of the sky, after the author had spent much time in examining and criticizing the different methods which had been adopted for the determination of the direction of the solar motion. The subject was brought into a clearer and more exact shape by the analytical formulation given to it by Professor Eddington, and after him by Professor Schwarzschild.

This star-streaming is corroborated by observations of velocities in the line of sight. It applies—with the exception of the helium stars—to all stars which are near enough for their proper motions to be determinable. We may say with certainty that it extends to stars at distances of two or three hundred parsecs; it may extend much further, but I do not think we have at present much evidence of this. Professor Turner pointed out that the convergence of proper motions did not necessarily imply movements in parallel directions, and suggested that the star-streams were movements of stars to and from a center. The agreement of the radial velocities with the proper motions seems to me to be opposed to this suggestion, and to show that star-streaming indicates approximate parallelism in two opposite directions in the motions of the stars examined. As the great majority of these stars are comparatively near to us, it is possible that this parallelism is mainly confined to them, and indicates the general directions

of the orbital motions of stars in the neighborhood. An attempted explanation on these lines, as on Professor Turner's, implies that the sun is some distance from the center of the stellar system.

A discovery of an entirely different character was made by Professor Boss in 1908. He spent many years in constructing a great catalogue giving the most accurate positions and motions of 6,200 stars obtainable from all existing observations. This catalogue, which was published by the Carnegie Institution, was intended as a preliminary to a still larger one which would give the accurate positions and motions of all the stars down to the seventh magnitude. In the course of this work Professor Boss found that forty or fifty stars scattered over a considerable region of the sky near the constellation Taurus were all moving towards the same point in the sky and with nearly the same angular velocity. He inferred that these stars were all moving in parallel directions with an equal linear velocity, and the supposition was verified, in the case of several of them, by the determination of their radial velocities. From these data he was able to derive the distance of each star and thus its position in space. The existence of a large group of stars, separated from one another by great distances, and all having the same motion in space, is a very remarkable phenomenon. It shows, as was pointed out by Professor Eddington, how small is the gravitational action of one star on another, and that the movement of each star is determined by the total attraction of the whole mass of the stars. Several other interesting moving clusters have been found since. For all the stars belonging to these clusters, the distances have been found, and from them luminosities and velocities of individual stars, particulars which are generally only obtainable for stars much nearer to us.

Proper motions are the main source of our knowledge of the distances of stars which are beyond the reach of determination by annual parallax. If a star were known to be at rest its distance could be calculated from the shift of its apparent position caused by the translation of the solar motion. As the solar system moves 410 times the distance of the earth from the sun in a century, this gives a displacement of 1″ for a star at the distance of 500 parsecs. This method has been applied by Kapteyn to determine the distances of the helium stars, as their velocities are sufficiently small to be neglected in comparison with that of the solar system. But generally it is only possible to find the mean distances of groups of stars of such size that it may be assumed that the peculiar motions neutralize one another in the mean. For example, the average distance of stars of type A, or stars of the fifth magnitude, or any other group desired may be found. In this way Kapteyn has found from the Bradley stars that the mean parallax of stars of magnitude m is given by the formula

$$\log. \pi_m = -1.108 - 0.125\ m.$$

In conjunction with another observational law which expresses the number of stars as a function of the magnitude, this leads to a determination of the density of stars in space at different distances from us, and also of the "luminosity law," *i. e.*, the percentage of stars of different absolute brightness. Professors Seeliger and Kapteyn have shown in this way that there is a considerable falling off of star-density as we go further from the solar system. It seems to me very necessary that this should be investigated in greater detail for different parts of the sky separately. A general mathematical solution of general questions which arise in the treatment of astronom-

ical statistics has been given by Professor Schwarzschild. His investigations are of the greatest value in showing the exact dependence of the density, luminosity and velocity laws on the statistical facts which can be collected from observation. The many interesting statistical studies which have been made are liable to be rather bewildering without the guidance furnished by a general mathematical survey of the whole position.

When the proper motions are considered in relation to the spectral types of the stars, the small average velocities of the hydrogen stars and still smaller ones of the helium stars found from line-of-sight observations are confirmed. If stars up to a definite limit of apparent magnitude, say, to 6.0 m., or between certain limits, say 8.0 m. and 9.0 m., are considered, then the solar stars are found to be much nearer than either the red or the blue stars. Thus both red and blue stars must be of greater intrinsic luminosity than the solar stars. As regards blue stars, this agrees with results given by parallax observations. But the red stars appear to consist of two classes, one of great and one of feeble luminosity, and it does not seem that a sufficient explanation is given by the fact that a selection of stars brighter than any given apparent magnitude will include the very luminous stars which are at a great distance, but only such stars of feeble luminosity as are very near.

The significance of these facts was pointed out by Professor Hertzsprung and Professor Russell. They have a very important bearing on the question of stellar evolution, a subject for discussion at a later meeting this week. From the geometrical point of view of my address these facts are of importance in that they help to classify the extraordinarily large range found in the luminosities of stars. Putting the matter somewhat broadly, the A stars, or hydrogen stars, are on the average intrinsically 5 magnitudes brighter than the sun, whilst the range in their magnitudes is such that half of them are within $\frac{3}{4}$ magnitude of the mean value. The stars of type M, very red stars, are of two classes. Some of them are as luminous as the A stars, and have a similar range about a mean value 5 magnitudes brighter than the sun. Others, on the contrary, have a mean intrinsic brightness 5 magnitudes fainter than the sun and with the same probable deviation of $\frac{3}{4}$ magnitude. Between the types M and A there are two classes the distance apart of which diminishes as the stars become bluer. The facts in support of this contention are very forcibly presented by Professor Russell in *Nature* in May, 1914. If this hypothesis is true, and it seems to me there is much to be said in its favor, then the apparent magnitude combined with the type of spectrum will give a very fair approximation to the distances of stars which are too far away for their proper motions to be determinable with accuracy.

In dealing with the proper motions of the brighter stars, the sky has been considered as a whole. Now that the direction and amount of the solar motion are known, we may hope that, as more proper motions become available, the different parts of the sky will be studied separately. In this way we shall obtain more detailed knowledge of the streaming, and also of the mean distances of stars of different magnitudes in all parts of the sky, leading to a determination of how the density of stars in space changes in different directions. A second line of research which may be expected to give important results is in the relationship of proper motions to spectral type. There is in preparation at Harvard College by Miss Cannon, under Professor Pickering's direction, a catalogue giving the type of

spectrum of every star brighter than the ninth magnitude. It would be very desirable to determine the proper motions of all these stars. If all the material available is examined it should be possible to do this to a very large extent.

PHOTOMETRY AND COLOR

For the more distant parts of the heavens proper motions are an uncertain guide, and we must depend on what can be learned from the light of the stars by means of stellar photometry, determinations of color, and studies of stellar spectra. Speaking generally, we attempt to discover from the nearer stars sufficient about their intrinsic luminosities to enable us to use the apparent magnitude as an index of the distances of the stars which are further away. The most striking example is found in Professor Hertzsprung's determination of the distance of the small Magellanic cloud. From a knowledge of the characteristics of the Cepheid variables found in this cloud by Miss Leavitt, and their apparent magnitude, he deduced the distance of the cloud as 10,000 parsecs.

Much attention has been given of late years to stellar photometry. In 1899 Professor Pickering published the Revised Harvard Photometry giving the magnitudes of all stars brighter than 6.5 m. In 1907 Messrs. Müller and Kempf completed a determination of 14,199 stars of the northern hemisphere brighter than 7.5 m. In 1908 a catalogue of 36,682 stars fainter than 6.5 m. was published at Harvard. These determinations derive additional importance as they give the means of standardizing estimates of magnitude made by eye, particularly the many thousands of the Bonn Durchmusterung.

By the labors of Professor Pickering and his colleagues at Harvard, Professor Schwarzschild, Professor Parkhurst at Yerkes, Professor Seares at Mount Wilson, and others, the determinations of the magnitudes of stars by photography has made rapid strides. As yet no complete catalogues of photographic magnitude corresponding to the Revised Harvard Photometry have been published, though considerable parts of the sky and special areas, such as the Pleiades, have been carefully studied. The determination of the photographic magnitudes of any stars which may be required is, however, a comparatively simple matter when the magnitudes of sufficient standard stars have been found. A trustworthy and uniform scale has been to a large extent secured by the use of extra-focal images, gratings and screens in front of the object glass, and the study of the effects of different apertures and different times of exposure.

At Harvard and Mount Wilson, standard magnitudes of stars near the north pole have been published extending to nearly the twentieth magnitude. In the part of the range extending from 10.0 m. to 16.0 m. these agree very satisfactorily. There is, however, a difference of 0.4 m. in the scale between 6.0 m. and 10.0 m. which needs to be cleared up.

A uniform and accurate scale of magnitude is of fundamental importance in counts of the numbers of stars. Such counts aim at the determination of two things: (1) how the numbers vary in different parts of the sky, and (2) what is the ratio of the number of stars of each magnitude to that of the preceding magnitude in the same area of the sky. The counts of stars from the gauges of Sir William and Sir John Herschel, those of the stars contained in the Bonn Durchmusterung, those made by Professor Celoria, and the recent counts of the Franklin-Adams plates by Dr. Chapman and Mr. Melotte, all agree in showing a continuous increase of stars as we proceed

from the pole of the galaxy to the galaxy itself. The importance of this fact is that it shows a close connection between the Milky Way and the stars nearer to us. The Milky Way is not a system of stars beyond the others, but is the primary feature of our "island universe."

Photometric observations have acquired additional importance from the differences between photographic and visual magnitudes. The ordinary plate is more sensitive to blue light than the eye, and the difference between the photographic and visual (or photo-visual) magnitude of a star is an index of the color. The color index is found by observation to be related very closely to the type of spectrum. Professor Seares has shown from the color indices that as the stars become fainter they become progressively redder. Professor Hertzsprung has found the same thing by the use of a grating in front of the object glass. Among stars of 17.0 m. visual magnitude, Seares found none with a color index less than 0.7; this is approximately the color index of a star of solar type, *i. e.*, near the middle of the range from blue stars to red stars.

There are three ways in which this may occur. The stars may be bright but very distant red stars; or they may be faint red stars, like those in the immediate neighborhood of the sun; or there may have been an absorption of blue light. It is not possible to say in what proportion these causes have contributed. The red stars of 9.0 m. and 10.0 m. are nearly all very luminous but distant bodies, but it seems likely that stars of 17.0 m. will contain a greater proportion of stars of small luminosity.

The absorption of light in space is very small, and as yet imperfectly determined. Professor Kapteyn and Mr. Jones, by comparing the color indices of stars of large and small proper motion, make the difference between the absorption of photographic and visual light as 1 m. in 2,000 parsecs. The question has been examined directly by Professor Adams, who has obtained spectra of near and distant stars which are identical as regards their lines, and has examined the distribution of the continuous light. This direct method of comparison showed that the more distant star was always weaker in violet light. But as both these investigations show that very luminous stars are intrinsically somewhat bluer than less luminous stars of the same spectral type, the two causes require further research for their disentanglement. The question is of importance, as it may serve in some cases to determine the distances of very remote bodies the type of spectrum of which is known.

It must be admitted that we are as yet very ignorant of the more distant parts of the "island universe." For example, we can make little more than guesses at the distance of the Milky Way, or say what part is nearest to us, what are its movements, and so on. But, nevertheless, the whole subject of the construction of the heavens has been opened up in a remarkable manner in the last few years. The methods now employed seem competent to produce a tolerably good model showing the coordinates and velocities of the stars as well as their effective temperatures and the amount of light they radiate. Industry in the collection of accurate data is required, along with constant attempts to interpret them as they are collected. The more accurate and detailed our knowledge of the stellar system as it is now, the better will be our position for the dynamical and physical study of its history and evolution.

F. W. DYSON

THE ROYAL OBSERVATORY,
GREENWICH

A NEW PROFESSION

The following extracts from a paper entitled "Applied Biology, A New Profession," emphasizing the opportunities for men in sanitary engineering, public health work and municipal engineering was read before the Civil and Sanitary Engineering Section of the Alumni Convention at Pittsburgh, February 20, and the complete article can be found in the reports of the convention.

With increasing urbanization caused by the flux from the country districts to the cities and all the results which accrue from the consequent overcrowding and the extension to a greater number of people of an artificial mode of living, the chances for morbidity and mortality are greatly increased. To offset these conditions and to minimize these dangers, there has grown up in the last quarter century a new profession, sanitary science or preventive medicine, concerned with the prevention and control of disease rather than with cure, and as the proverbial "ounce of prevention" is still "worth a pound of cure" and as the increase of perplexing problems, which are the outgrowth of these constantly extending artificial conditions, is apparent, the new profession would be justified even if the brilliant deeds it has accomplished, during the few years it has been in existence, were unknown. Those of you who are interested in this work know of many instances in your own experience to corroborate my assertion. That this new field is entirely distinct from that of curative medicine and that it contains many problems which the ordinary physician is not fitted either by training or by experience to solve, is proved by the fact that our more progressive medical schools are offering a three-year post-graduate course to their students, in order that they may be properly qualified to cope with the problems of sanitary science.

The following extract from the health bulletin of one of our most progressive states further emphasizes this point. "The practise often followed of naming the leading practitioner as health officer is by no means indicative of a good choice. It is probably more often the reverse. A physician becomes a competent practitioner only after intelligent and arduous study of curative measures. The more successful he is the more he has specialized in his chosen work to the exclusion of those particular sciences that have to do with preventive measures."

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For those of you who are interested chiefly in the engineering side of public health work, it is desirable to review the applications of biology to sanitary science, in order to make clear the great number of points at which this subject touches the welfare of humanity. There is, perhaps, no better way of doing this than by examining the curriculum of that institution which was a pioneer in this field and noting the practical applications of the various subjects therein contained.

First and foremost in this curriculum comes the course in general biology, which is the study of the physics and chemistry of living matter, and if our thesis is that we are trying to improve human living conditions and better the environment of mankind in general, what better way is there of approaching a solution of this difficult problem than by studying the simpler forms and their correspondingly simpler reactions to changes in their environment? And what subject more fundamental could be imagined than that one, which from its very name means the study of living things?

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An independent piece of research work, a thesis, is also required and this tends to develop the resourcefulness of the individual when he is thrown upon his own responsibility. To the pragmatist, who claims that the work of the investigator in pure science has no practical value, it is but necessary to point out there is only a very little research that sooner or later does not meet with a practical application; the pure science of to-day becoming the applied science of to-morrow. On completion of this course, the student in biology has a four-fold possibility before him: first, openings in the various fields of public health work; second, positions in the fermentation industries; third, teaching positions, either in biology or its practical applications; fourth, an opportunity to build upon this excellent foundation a medical education.

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The supply of persons properly trained to teach biology, especially its applications to public health work and of those adequately equipped to occupy field positions, is far below the demand. One finds in many of these positions, incompetent men; men who are not fitted by either training or experience to solve problems related to the public health in a sound, rational, scientific manner, but who work by some rule of thumb method or dispose of their problems in a manner similar to that of the alchemists of the middle ages. It is true

that there are many unsolved questions in this nearly virgin field, and because of this and for the further reason that our cities still continue to enlarge, thus increasing our needs for sanitation, the opportunities in this field, especially in our rapidly growing west and middle west, are legion and because of these facts advance in most of the positions is comparatively rapid. This training enables a person to guide in a scientific manner such important movements as tuberculosis control, the establishment of milk depots, school inspection, the proper collection of vital statistics, proper housing, public health organization, in fact any question dealing with or intimately associated with matters pertaining to the conservation of life.

In this new field, we find sanitary biologists, sanitary engineers and sanitary chemists working together for a solution of such problems as providing a safe water supply and sewerage system, controlling epidemics of disease, enforcing proper care in the handling of food materials, in short, attempting the best solution of the particular public health problems which confront any given community.

. . . . . .

There is no subject of greater interest to people in general than that of their own health and they recognize that this is closely related to questions of public health, for on the subject of disease and death we all meet on common ground. Because of this interest, the subject is much discussed, and it is not surprising to find much misinformation afloat because persons often appoint themselves authority pro-tem in social gatherings, and give decisions which have no background of fact or wisdom. A short time ago I heard from a reliable source that a man in a public health position said that typhoid carriers could be detected by blood cultures and from another "authority" came the statement that a T-bone steak, in the bottom of a well, was responsible for an outbreak of typhoid fever which occurred in the community in which the well was situated. Later I received a graphic description of how hordes of typhoid germs sallied forth from the carcass of a horse which was in a river bed, and calmly awaited unsuspecting persons drinking from the stream.

Unscrupulous persons, either in their desire for publicity or in order to "grind an axe" of their own, take advantage of this desire on the part of the public to be informed on health matters, by uttering half-truths or deliberately trifling with facts, to such an extent that wrong ideas gain ground and it takes much time to eradicate these false impressions. By such unscrupulous persons, the march of progress is materially hindered. Politicians and others with no knowledge of public health matters and not appreciating the gravity of their deeds sometimes depose good men or so curtail their powers that they are unable to discharge their duties efficiently or to serve the best interests of the community.

. . . . . .

It is over a half century since the theory of spontaneous generation or abiogenesis was finally overthrown, and while no one at the present time believes that eels can arise de novo from mud and slime or that mice can be generated from dirty flannel and corn, the idea is still current that decaying material and the consequent evil odors; poor plumbing; the "catching" of cold; etc., per se provide a suitable environment for generating disease-producing microorganisms. Nothing could be further from the truth, for a study of biology teaches us that between the living and non-living world we have one of the best defined barriers in nature, and that no living material, not even the humblest bacterial cell, comes into existence without the intervention of preexisting life of the same type.

Again quoting from one of our monthly state health bulletins: "Removing health departments from politics; selecting the right man, paying him the right salary, and permanent tenure of the position will do much to correct existing evils. There is no official of more importance to any community than a conscientious and capable health officer. The conserver of the health of our people is a benefactor of the race and worthy of the highest honors in the gift of the state."

. . . . . .

In closing allow me to quote Disraeli and express my strong sympathy with his ideas: "The public health is the foundation on which reposes the happiness of the people and the power of the country. The care of the public health is the first duty of a statesman."

J. E. RUSH

DEPT. OF BIOLOGY AND PUBLIC HEALTH,
CARNEGIE INSTITUTE OF TECHNOLOGY

THE SECOND PAN-AMERICAN SCIENTIFIC CONGRESS AND ITS SECTION OF ANTHROPOLOGY

IN accordance with the resolutions of the First Pan-American Scientific Congress, held in Santiago, Chile, December 25, 1908, to

January 5, 1909, a Second Pan-American Scientific Congress will meet in Washington next December under the auspices of the government of the United States. The congress will open on Monday, December 27, 1915, and adjourn on Saturday, January 8, 1916.

The executive committee of the congress is as follows:

William Phillips, A.B., third assistant secretary of state, chairman *ex-officio*.

James Brown Scott, J.U.D., secretary, Carnegie Endowment for International Peace, vice chairman.

William H. Welch, M.D., LL.D., president, National Academy of Sciences, honorary vice chairman.

John Barrett, LL.D., director general, Pan-American Union.

W. H. Bixby, Brigadier General, U. S. A., retired.

Philander P. Claxton, LL.D., commissioner of education.

William C. Gorgas, M.D., Sc.D., surgeon general, U. S. A.

William H. Holmes, B.S., head curator, Smithsonian Institution.

Hennen Jennings, C.E., former president, London Institution Mining and Metallurgy.

George M. Rommel, B.S., chief, Animal Husbandry Division, Bureau of Animal Industry, Department of Agriculture.

L. S. Rowe, Ph.D., president, American Academy of Political and Social Science.

Robert S. Woodward, Ph.D., president, Carnegie Institution of Washington.

The organization officers are:

John Barrett, LL.D., secretary general.

Glen Levin Swiggett, Ph.D., assistant secretary general.

The headquarters are at the Pan-American Union, Washington, D. C.

The Pan-American Scientific Congress had its origin in the scientific congresses that had been held by the republics of Latin America prior to the congress in Santiago, and was established with the generous conviction that the United States should share in their undertaking. This conviction was splendidly shown in the unsolicited and voluntary action of the first congress in the selection of Washington as the place of meeting of the second congress, the main purpose of which will be to increase the exchange of knowledge and bring about a better understanding of the ways in which the several republics can work to the advancement of science, the increase of culture and the promotion of trade, commerce and mutual helpfulness. In view of the fact that this second congress is to be held under the auspices of the government of the United States, it is earnestly hoped that our foremost scientists, learned societies and educational institutions will cooperate in every way possible in order to insure the success of the congress.

The nine main sections of the program of the congress, with the name of the chairman in charge of each section, are as follows:

I. Anthropology, Mr. William H. Holmes.
II. Astronomy, Meteorology and Seismology, Mr. Robert S. Woodward.
III. Conservation of Natural Resources, Agriculture, Irrigation and Forestry, Mr. George M. Rommel.
IV. Education, Mr. P. P. Claxton.
V. Engineering, General W. H. Bixby.
VI. International Law, Public Law and Jurisprudence, Mr. James Brown Scott.
VII. Mining and Metallurgy, Economic Geology and Applied Chemistry, Mr. Hennen Jennings.
VIII. Public Health and Medical Science, General Wm. C. Gorgas.
IX. Transportation, Commerce, Finance and Taxation, Mr. L. S. Rowe.

Each section is divided further into subsections. There are forty-five of the latter in all, each with a special committee and program. The deliberations of the congress will be based, in consequence, according to the subject-matter to be discussed in the various sub-sections. In addition to the general sessions of the congress, there will be joint sessions between the different sections and subsections. Several of the leading national associations of the United States, concerned with the investigation of subjects of pertinent interest to some of the sections of the congress, have received and accepted invitations from the executive committee of the Second Pan-American Scientific Congress to meet in Washington at the same time and hold one or more

joint sessions with a section or sub-section of corresponding interest.

The following persons will be members of the congress:

The official delegates of the countries represented.

The representatives of the universities, institutes, societies and scientific bodies of the countries represented.

Such persons in the countries participating in the congress as may be invited by the executive committee, with the approval of the countries represented.

All writers of papers.

All members of the congress shall be entitled to attend its sessions, to take part in the debates, and to receive a copy of such publications as the executive committee may issue. There will be no membership fee of any character.

The interest throughout Latin America for the congress is steadily growing. The executive committee is assured that all of these countries appreciate deeply the active preparations now being made in Washington for a successful meeting, and will avail themselves generously of this great opportunity for Pan-American solidarity of action in intellectual interests. Each of the participating Latin American countries, eighteen in number, has been invited to appoint a committee to cooperate with the executive committee of the congress and to make such arrangements as will insure the most generous participation of each country in the congress through the attendance of delegates and representation on the program. A feature of particular importance and appealing interest to the Latin American countries is that of the special Pan-American topics which will be discussed at the time of the congress in a series of conferences. The various sections of the congress, and in some cases the different sub-sections, have designated certain topics to be discussed in this manner. Each country has been invited to select its most eminent writers to prepare papers on these topics, one person for each topic.

Section I will discuss such subjects as relate to the origin, development and distribution of mankind into ethnic, social and political groups. Of particular interest are the topics which refer to the chronology of the American race and the evolution of its culture, and the complex of races and nationalities now constituting the Pan-American populations.

The chairman of this section is Mr. William Henry Holmes, head curator of anthropology, United States National Museum. Mr. Holmes is a member of the leading national and foreign societies devoted to research in the fields of archeology and anthropology. He was a delegate to the First Pan-American Scientific Congress, which met in Santiago, Chile, in 1908. Dr. Ales Hrdlicka, curator of the division of physical anthropology, United States National Museum, is the secretary of this section.

In addition to the chairman and the secretary, the committee in charge of the program of Section I includes the following representatives of important institutions, societies and other organizations devoted in whole or in part to the science of man:

F. W. Hodge, of the Bureau of American Ethnology, Smithsonian Institution.

Walter Hough, of the United States National Museum.

J. Walter Fewkes, of the National Academy of Sciences.

Roland B. Dixon, of Harvard University.

C. C. Willoughby, of the Peabody Museum of American Archeology and Ethnology, Harvard University.

George B. Gordon, of the University of Pennsylvania.

Frederick Starr, of the University of Chicago.

Albert Ernest Jenks, of the University of Minnesota.

Franz Boas, of Columbia University.

Hiram Bingham, of Yale University.

Warren K. Moorehead, of the Phillips Academy Museum, Andover, Mass.

A. L. Kroeber, of the University of California.

Elizabeth Duncan Putnam, of the Davenport Academy of Sciences, Davenport, Iowa.

Alice C. Fletcher, of the Archeological Institute of America.

Stewart Culin, of the Museum of the Brooklyn Institute of Arts and Sciences.

M. H. Saville, of the Heye Museum, New York.

S. A. Barrett, of the Milwaukee Public Museum.

George A. Dorsey, of the Field Museum of Natural History.

Arthur C. Parker, of the Museum of the State of New York.

C. F. Lummis, of the Southwest Museum, Los Angeles.

George Grant MacCurdy, of the Yale University Museum.

John R. Swanton, of the Anthropological Society of Washington.

T. Mitchell Prudden, of the American Ethnological Society, New York.

Clark Wissler, of the American Museum of Natural History, New York.

Pliny E. Goddard, of the American Folk-Lore Society.

Waldo Lincoln, of the American Antiquarian Society.

Sylvanus G. Morley, of the Carnegie Institution.

Edgar L. Hewett, of the School of American Archeology.

H. M. Whelpley, of the Missouri Historical Society.

J. C. Branner, of Leland Stanford Junior University.

Mr. W. C. Mills, of the Ohio State University.

For this section some of the most distinguished scientists in Pan-America have been invited to prepare papers on the subjects described in the preliminary program, edition of April 15, a copy of which may be obtained on request to the secretary general of the congress.

The following topic has been proposed by Section I for the series of Pan-American conferences: "The desirability of uniform laws throughout the Pan-American countries for the protection of antiquities, the systematic promotion of anthropological research and the collection and scientific treatment of museum materials."

The Nineteenth International Congress of Americanists will meet in Washington during the same week with the Pan-American Scientific Congress, and joint conferences will be held for the discussion of subjects of common interest to members of the two organizations. This will be especially advantageous, since a large number of students from all parts of America, as well as from the Old World, interested in these branches, will thus be brought together on common ground.

Glen Levin Swiggett,
Assistant Secretary General

SCIENTIFIC NOTES AND NEWS

At the Manchester meeting of the British Association for the Advancement of Science, Sir Arthur J. Evans, F.R.S., the archeologist, honorary keeper of the Ashmolean Museum, Oxford, was elected president for next year's meeting, to be held at Newcastle-on-Tyne. The meeting of 1917 will be held at Bournemouth.

A. Gibb Maitland, director of the geological Survey, Western Australia, has been elected president of the Royal Society of Western Australia for the ensuing session.

The International Engineering Congress met at San Francisco from September 20 to 25. Major-general G. W. Goethals, honorary president of the congress, delivered the principal address.

The office of state entomologist has recently been established in Wisconsin, to take over the nursery and orchard inspection and administration of the laws governing insecticides and fungicides. It is to be independent of the University of Wisconsin, with headquarters in the state capitol at Madison. Professor J. G. Sanders goes from the College of Agriculture to be the first incumbent of the office and Dr. S. B. Fracker, instructor in the same department, has been appointed assistant entomologist.

Professor Ewald Hering, the eminent physiologist of Leipzig University, will retire at the close of the winter semester.

Dr. Charles K. Mills has resigned from the medical faculty of the University of Pennsylvania, where since 1893 he had been professor of mental diseases and of neurology.

Professor Anthony Zeleny, of the University of Minnesota, has this year leave of absence and will spend the time in research in physics at Princeton University.

THE Detroit board of health has been authorized to employ a laboratory expert as head of the Pasteur Institute and J. B. Kelly, Ann Arbor, has been elected to the position.

MR. F. A. FENTON, a graduate student of the University of Wisconsin and for a time deputy nursery inspector in the same state, has joined the Federal Bureau of Entomology and will be engaged in work with Mr. J. J. Davis at Lafayette, Indiana.

DR. N. ANNANDALE, superintendent of the Indian Museum, Calcutta, is to spend the greater part of a six months' leave of absence in Siam and Japan, studying the fauna of the lake regions.

WE learn from *Nature* that in commemoration of Captain Cook, a tablet has been placed on the school at Great Ayton, Cleveland, where the navigator received his education; a scholarship has also been established at Marton, in the same neighborhood, which was Captain Cook's birthplace. The cost of both has been provided out of the surplus of the fund raised for the erection of the Cook memorial in London.

DR. AUSTIN FLINT, a distinguished physician and alienist of New York City, long professor of physiology in the Bellevue Hospital Medical College and the Medical College of Cornell University, died on September 22, at the age of seventy-nine years.

DR. H. H. MCGREGOR, formerly instructor in chemistry, Adelbert College, and recently appointed instructor in biochemistry at the medical school, Western Reserve University, has died of typhoid fever in Toronto, Canada.

BESIDES the biological expedition to British Honduras, mentioned in these columns, the St. Louis University had a geological expedition in the field during the summer months. The personnel of the latter was Professors W. H. Agnew, J. Knipscher, H. F. Sloctemyer, J. A. Krance, A. H. Poetker, J. B. Macelwane, of the St. Louis University; Professors P. J. Troy and T. J. Motherway, of St. Mary's College, St. Marys, Kan.; Professor J. A. Kilian, of St. John's University, Toledo, Ohio, and Professor R. E. Connolly, of Campion College, Prairie du Chien, Wis. The task assigned to the party was a threefold one. They were to undertake a preliminary study of the petrified forests of eastern Arizona; to investigate a number of structural and stratigraphic details in the Bright Angel Quadrangle of the Grand Canyon of the Colorado; and, after visiting several points of geologic interest on the Pacific coast, to make a general reconnaissance of the Pre-Cambrian, Cambrian and Pleistocene geology of parts of the Cordillera along the Canadian Pacific Railway. The members of the party secured a considerable quantity of valuable material from each of these regions, including a collection of Middle Cambrian trilobites and brachiopods from Mts. Stephen and Field. They also obtained a larger number of excellent photographs for laboratory and class-room illustration.

MR. W. J. WINTEMBERG, of the Geological Survey, Ottawa, has returned from a successful archeological exploration at the prehistoric Iroquoian site near Roebuck, Ontario. He succeeded in mapping the traces of a palisade across the farm of Nathaniel White which, because it was under crop, was not excavated by Mr. Wintemberg in 1912 when he explored the greater part of the Roebuck site. This season's exploration also resulted in securing thirty-three human skeletons and eleven boxes of objects made by the prehistoric people of the place. Many of the skeletons were photographed in situ. Several of these skeletons show conclusively that the people suffered from terrible diseases which caused growths upon the bones, and the abnormal union of certain bones. Their teeth also gave them great trouble. Among the important specimens found were an unfinished comb made of antler and two barbed fish hooks made of bone. Many fragments of pottery and of pipes made of pottery were also found. Some of the latter are sculptured to represent the human face and are of artistic merit.

UNIVERSITY AND EDUCATIONAL NEWS

THE board of trustees of the Ohio State University, Columbus, has authorized the establishment of a department of public health

and sanitation, which has been organized with the following appointments: Eugene M. McCampbell, M.D., professor of preventive medicine and head of the department; Robert G. Patterson, A.B., A.M., assistant professor of public health; Emery R. Hayhurst, M.D., assistant professor of industrial hygiene; William H. Dittoe, C. E., instructor in public health engineering; Frank G. Boudreau, M.D., instructor in public health and sanitation; Lear H. Van Buskirk, B.Sc., instructor in public health laboratory methods.

The following appointments have been made to the faculty of Case School of Applied Science: Keith F. Adamson, the University of Pennsylvania, assistant professor of mechanical engineering; Melville F. Coolbaugh, the South Dakota School of Mines, assistant professor of chemistry; Roy E. Spencer, Harvard University, instructor in English; Lawrence G. Wesson, Harvard University, instructor in organic chemistry; Carl H. Wilson, Harvard University, instructor in chemistry; Arthur E. Bradley, recently of Cornell University, instructor in civil engineering; Allan A. Prior, Harvard University, instructor in electrical engineering; Perry F. Ellsworth, the Edison Electric Company, instructor in electricity and drawing; R. B. Reis, the Westinghouse Electric Company, instructor in mechanical engineering; H. F. Pasini, graduate of the Y. M. C. A. Training School of Springfield, director of the gymnasium; Bohlis Dahlman, instructor in gymnastics.

Professor H. F. Wilson, of Oregon State College, has gone to the University of Wisconsin as professor of economic entomology to take the place of Professor J. G. Sanders, who has become state entomologist for Wisconsin.

Dr. R. G. Pearce, associate in physiology, Western Reserve University, has been appointed assistant professor of physiology in the college of medicine, University of Illinois, Chicago.

Dr. James Craig Neel has been appointed instructor in obstetrics and gynecology (on an academic basis) in the University of California Medical School.

S. H. E. Barraclough, lecturer at the University of Sydney, has been appointed to the chair of mechanical engineering.

DISCUSSION AND CORRESPONDENCE

A PROPOSED CLASSIFICATION OF THE ATTITUDE OF GEOLOGIC SURFACES

The familiar classification of folds has long been used by the geologist in working with oil and gas. Its inadequacy for his purposes is apparent when one considers that the determining factor in the gravitational separation of gas, oil and water is not the general plane of the bed, but the actual surface constituting the roof or floor of the reservoir. This may differ from the general plane of the bed due not only to irregularity of deposition, but also to irregularity of cementation, since the reservoir frequently constitutes only a portion of the sandstone bed. A mere classification of folds will not suffice, because it is the upper or the lower surface which concerns us, and they are frequently not parallel.

A lenticular bed which lies in general horizontal is not a fold at all, nor is one lying in a plane monocline. Yet the upper and lower surfaces of either of these have an attitude which is of great moment to the oil geologist, and must be considered along with the folded surfaces.

The following classification of geological surfaces is therefore presented here in the belief that it will be applicable to other geological problems as well as to those of the oil and gas geologist. There are four prime divisions:

1. Acline—no inclination.
2. Monocline—inclination in one general direction.
3. Anticline—inclination away from a point or axis.
4. Syncline—inclination toward a point or axis.

Acline

The acline is of small importance because one finds so generally that there is at least a

slight inclination to beds, either deformational or depositional. The terrace is an acline interrupting a monocline which continues with the same dip direction both above and below the acline.

The horizontal bed is rare because (*a*) beds are generally laid down on a shore which is an inclined surface, and (*b*) when the shore is raised at the time of emergence some tilting will usually result. Even if as a whole it is flat, the upper and lower surfaces are likely to have an inclination because of differences in deposition, compacting or cementation.

Monocline

"Monocline" is a much-abused term. Some authors use it for what Scott more discriminatingly calls a monoclinal *flexure*—"a single sharp bend connecting strata which lie at different levels and often horizontal except along the line of flexure." A more desirable use is that of Grabau, Chamberlain and Salisbury, and the Century Dictionary, who follow the author of the term, H. D. Rogers, in applying it simply to beds "dipping in one direction."

The monocline may be subdivided into three primary types:

1. The plane monocline—all surfaces having a roughly similar degree of dip.

2. The anti-monocline is a curved portion of a monocline which is convex, when seen from a point perpendicular to the general surface and above it. This is a very common structure. It is readily seen that it is analogous to an anticline and would become one if the surface in general were tilted to a more horizontal position. Similarly, an anticline tilted sufficiently becomes an anti-monocline. Orton, with this aspect in mind, called it an "arrested anticline."

3. The syn-monocline is a curved portion of a monocline which is concave when seen from a point perpendicular to the general surface and above it. It bears the same relation to a syncline that the anti-monocline does to the anticline.

4. The monoclinal flexure. In addition to these fundamental units there is the very common combination of an anti-monocline passing directly into a syn-monocline below it. For this the term monoclinal flexure has long been used. To restrict the word monocline to this structure as some geologists have done is very objectionable.

5. Half-fold. This same combination is found in the half-fold, which is the whole surface from the axis of an erect anticline to the axis of an adjoining syncline; or if the anticline springs from a plane, to that plane.

Anticline

Anticlines are divisible into the following classes:

1. The *dome* is a surface dipping outwardly in all directions from a central point or line.

2. The *level axis anticline* is one where the surface is in general horizontal along the axis of the anticline. A very elongate dome may have a middle portion which is also a level axis anticline.

3. The *plunging anticline* is one having the axis itself inclined. An elongate dome is made up of two plunging anticlines, the plunges being in general in opposite directions. As stated above, a level axis anticline may intervene.

4. *Nose.* Two anticlines may cross each other. This generally produces a more or less marked dome at the intersection, which has radiating plunging axes. The anticlines are seldom of equal magnitude. If one of them is very much less than the other, it is seen merely as a wrinkle in the flank of the larger one. Since these are very common and confusion arises if they are called anticlines without qualification, the descriptive name of *nose* is proposed. A *nose* is a relatively minor plunging anticline on the flank of a much larger anticline or syncline or in a monocline. It causes the isobaths to show a mere wave in the down-dip direction.

Synclines

Applying the foregoing distinctions to synclines, we have the opposite terms—*basin, level axis syncline, plunging syncline* and *chute.*

The term *chute,* while new in this connection, is needed. It may be defined as a "minor plunging syncline on the flank of a much larger anticline or syncline or in a monocline." It causes the isobaths to make a wave in the up-dip direction.

Saddles

A saddle is a down fold in the axis of an anticline, or an up fold in the axis of a syncline. This form partakes of the nature of both an anticline and a syncline, as is evident if a model in sheet lead is turned upside down—when we find it is still a saddle, but at right angles to the original one.

For surfaces involved in recumbent, erect, carinate, isoclinal or fan folds, the present fold terms may be used without modification.

The greatly increased use of the geologic surface in economic geology has led to the proposal of this specific set of terms, for which the current nomenclature of folds was not adequate.

Roswell H. Johnson
University of Pittsburgh

The Origin of the "Niter Spots" in Certain Western Soils

In an article entitled "The Origin of the 'Niter Spots' in Certain Western Soils," which appeared in the *Journal* of the American Society of Agronomy, Vol. 6, No. 6, Professors Stewart and Peterson of the Utah Experiment Station state on pages 246, 247 and 248 of the publication cited, that,

> The brown color of the "niter spots" is produced by the solvent and decomposing action of the sodium nitrate upon the organic matter of the soil in just the same way that the black color of the black alkali spots is produced by the solvent and decomposing action of the sodium carbonate upon the soil organic matter. . . .
>
> The color (of the black alkali) is produced by the sodium carbonate, because, being the salt of a weak acid and a strong base, it readily hydrolyzes, producing sodium hydroxide, or caustic soda, which, as is well known, acts on carbohydrates, producing a brown color, the intensity of which depends on the concentration of the sodium or potassium hydroxide, thus readily accounting for the production of the color of black alkali. *Likewise, in the case of sodium or potassium nitrate, the salt being the result of this union of a strong base and a stronger acid than carbonic acid, does not hydrolyze so easily and as a result there is a smaller amount of sodium or potassium hydroxide present and necessarily the production of a milder color as observed in the brown alkali (niter) spots. The sodium and potassium sulphate and chloride, being the salts of strong acids and bases, do not hydrolyze, therefore caustic alkali is not produced, and consequently the color is not produced by these alkali salts.*

It will be seen that while the authors state that the alkali sulphates and chlorides are not hydrolyzed at all, being the salts of strong acids and strong bases, they assert that the nitrates are hydrolyzed, though to a less extent than the carbonates, being the salts of a stronger acid than carbonic. The natural inference is that the authors regard nitric acid as being a weaker acid than either hydrochloric or sulphuric.

It has long been recognized that the strength of acids depends upon their degree of ionization. In the third English edition of Treadwell's "Analytical Chemistry," Vol I., p. 16, we find that in $N/10$ solution, nitric and hydrochloric acids are both ionized in the extent of approximately 90 per cent., while in the third English edition of Ostwald's "Principles of Inorganic Chemistry," p. 248, we find the extent of the ionization of hydrochloric acid in $N/10$ solution to be 95 per cent., while that of sulphuric acid is only 57 per cent. It is thus evident that the view, commonly accepted by chemists, that hydrochloric and nitric acids are of approximately equal strength, and that sulphuric acid is considerably less strong, is correct. Since the only salts of the alkalis which are hydrolyzed are their salts with weak acids, it is clear that the sulphates, being salts of a weaker acid than nitric, should be hydrolyzed to a greater extent than the nitrates.

On page 247, Table 8, of their article, Stewart and Peterson show that while a 1-per-cent. solution of sodium nitrate dissolved 0.8 per cent. of the organic matter of a given soil, a 1-per-cent. solution of sodium sulphate extracted 1.19 per cent. of it, that is to say, 48.75

per cent. more than the nitrate. We have shown that sodium sulphate should be hydrolyzed to a greater extent than sodium nitrate; consequently, it should have not only a greater solvent action than the nitrate, but also a greater decomposing action on the organic matter, resulting in the production of a darker brown color. In view of the very general and abundant distribution of alkali sulphates in western soils, and granting the presence of sufficient organic matter for the production of a brown color according to the hypothesis of Stewart and Peterson, we should expect to find a uniform distribution of a dark brown surface color throughout the soils of the arid west. This is not the case.

As a matter of fact, neither the nitrates nor the sulphates are hydrolyzed at all. Stewart and Peterson admit that the sulphates are not hydrolyzed, but claim that the nitrates are. It is indeed difficult to reconcile their claim with the facts in the case. Since the alkali nitrates are not hydrolyzed, and since alkali hydroxides could be produced from them in no other way than by their hydrolysis, it is very evident that no alkali hydroxides are formed, and consequently the explanation of the brown color of the "niter spots" as given by Stewart and Peterson is nothing short of preposterous.

The question raised by the above writers concerning the relation of the pigment of *Azotobacter chroococcum* and the nitrate to the brown color of the "niter spots" applies only to the colorless strains of the organism. These have been shown by us to be capable of producing abundant brown to black pigment when supplied with very small quantities of nitrate (0.01 to 0.03 per cent. sodium nitrate) and some source of energy, both of which are present in our niter soils. Aside from these colorless strains, their contention is wholly irrelevant for we have already pointed out[1] that four of the seven strains of *A. chroococcum,* isolated from niter soils have produced, at one time or another, pigments varying in color from a delicate cream, through the different shades of brown, to an intensive brownish black in the *total absence of nitrates,* thereby attesting their ability to produce the pigment independent of the nitrate.

[1] Colorado Experiment Station Bulletin, 179, p. 33, June, 1911.

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CALCULATION OF THE GAMMA FUNCTION

TO THE EDITOR OF SCIENCE: In SCIENCE, April 2, 1915, Dr. Raymond Pearl has described a method of obtaining an approximate value of log $\Gamma(n)$ by interpolating in a table of log-factorial n.

In a table he compares the values obtained by interpolation, by Forsyth's method of approximation, and those found by using the relation

$$\Gamma(n+1) = n(n-1)(n-2)\cdots(n-r)\Gamma(n-r)$$

in conjunction with Legendre's tables, calling the value obtained by the last method the "exact" value.

Dr. Pearl explains that this "exact" value derived its name from the exactness of the mathematical argument upon which it is based, and not from any special accuracy in the numerical values given under that heading and he disclaims any greater degree of accuracy than can be expected from the summation of a large number of seven-place logarithms.

As the subject to be investigated is not how closely the values obtained by different methods agree with one another but how closely the approximate to the true value of the function, I have calculated a "more exact" value for the cases given by Dr. Pearl, using Legendre's table and ten-place logarithms and I believe the values so obtained are correct within a half-unit of the seventh decimal place.

Another set of values has also been calculated by means of Pearson's approximation formula[1]

[1] "On a Formula for Determining $\Gamma(x+1)$," *Biometrika,* Vol. VI., p. 118.

$$\log\frac{\Gamma(x+1)}{x^x e^{-x}} = .3990899 + \tfrac{1}{2}\log x + .080929 \sin\frac{25°.623}{x}$$

or

$$\log \Gamma(x+1) = .6162372 + (x+\tfrac{1}{2})(\log x - \log e) + .080929 \sin \frac{25°.623}{x},$$

using seven-place logarithms except for the second or product term where ten-place logarithms were used to avoid introducing inaccuracies when x is large. This formula is also given in the introduction to "Tables for Statisticians and Biometricians" (Chicago University Press), on page lv, where unfortunately by a printer's error the value 0.3990899 is wrongly given as .03990899.

The various series of values are summarized in the following table.

VALUES OF LOG $\Gamma(n)$ BY DIFFERENT METHODS

n	Pearl's "Exact" Value	Pearl Forsyth	Pearl Using Δ^2	Pearl Using Δ^3	Pearson	"More Exact" Value
5.123	1.4613860	1.4613679	1.4619138	1.4615009	1.4613859	1.4613860
15.123	11.0834931	11.0834916	11.0835559	11.0834985	11.0834931	11 0834930
25.123	23.9637108	23.9637096	23.9637336	23.9637119	23.9637107	23.9637107
35.123	38.6594135	38.6594126	38.6594251	38.6594138	38.6594133	38.6594133
75.123	107.7498704	107.7498692	107.7498727	107.7498702[2]	107.7498702	107.7498702

The table shows that Dr. Pearl's "exact" value differs from the "more exact" value by two units in the seventh place for the larger values of n and in the case of $n = 75.123$ is inferior to the value found from interpolation when third differences are used.

A comparison of the values in the table leads to the following conclusions.

(i) For small values of n, up to about 5, it is preferable to use the exact method if Legendre's tables are available; in the absence of Legendre's tables the Pearson approximation formula should be used.

(ii) For larger values of n, as shown by the middle portion of the table, Pearson's formula is superior to the interpolation method and gives results which coincide with those found by the

(iii) For still larger values of n, 75 and upwards, the Pearson approximation formula and the interpolation method using third differences both give the true value to the seventh decimal place, but while the usefulness of the interpolation method is limited by the range of the existing tables of log-factorial n, that of the approximation method is not affected, provided a sufficient number of places be used in the logarithms of x and e when computing the second or product term.

P. F. Everitt

[2] Given as 107.7492870 in Dr. Pearl's article, being a misprint for the value given above, which I verified by recalculation.

THE POSITION OF REFERENCES IN JOURNAL ARTICLES

From one half to one per cent. of the space in the majority of scientific journals giving many references is wasted by the faulty position and arrangement of the references.

The amount of time wasted by the reader will depend on whether he is obliged to look up the references, or simply glances at them occasionally to see a date, or the name of an author or journal.

The word reference is defined here to mean the author's name, journal title (usually abbreviated), with the numbers for series, volume, pages and date. If any information from the original is also given, and printed at the bottom of a page outside the text, the whole is regarded as a foot-note, and is not considered here. "*Loc. cit.*," is regarded as a reference.

Most journals are printed with a solid page, at the foot of which are the references for that page, with the reference numbers indicated in the text, a separate line being given to each reference, except where extra space is required either because of grouping several references under one number, or because of unusual length of names.

Nearly one per cent. of the space used in printing articles and references in this way can be saved by giving each reference a number (the numbers to run consecutively), then printing all the references at the end of the article, leaving an extra-wide spacing between the period at the end of one reference and the next number, in order to catch the eye. There

is nothing new in this method, for it has been used at rare intervals for a number of years.

The following illustrations taken at random from a number of measurements, show the state of the case as regards chemical journals, but the proposition is equally true for the journals of other sciences. The measurements have been made on the supposition that the same sized type will be used in both ways of printing the references. A space of five millimeters is allowed between the period at the end of one reference and the beginning of the number of the next, and extra space is allowed for in the case of articles containing over ten references, for these will require the use of numbers with two figures. Thus, an article with sixty separate references printed in the customary way will have, as a rule, from two to eight references on the page, and rarely require the use of reference numbers with two figures, while the shorter way requires the use of numbers up to sixty both in the text and at the end of the article.

A consideration of those illustrations in which the number of pages with no references is given, will make two facts obvious; that the estimate of the amount of space saved is only a rough approximation; and that it might easily be possible by deliberate selection of one hundred pages to get results widely different from those given here.

In the leading English journal, the *Journal of the Chemical Society,* all the references are printed in the text, so that there is no saving of space. In the *Journal of the Society of Chemical Industry,* Volume 32, 457–995 (1913), containing 100 pages of text of articles, about one eighth of a page could be saved. This journal has two columns to the page. Several of the articles have all the references at the end of the article.

In the *Bulletin de la société chimique de France,* Volume 13, 320–457 (1913), containing 100 pages of text of articles, over one half a page could be saved. There are 62 pages with no references. Some of the articles have the references printed two to the line, with extra space between the two.

In the *Berichte der deutschen chemischen Gesellschaft,* Volume 45, 403–503 (1912), about one half a page could be saved. The references in this journal at present are greatly abbreviated, thus, B. stands for the title of *Berichte,* etc. If space allows, instead of printing the references one to a line, they are always printed two to a line, with a space of 5 to 15 millimeters between the two. This method (a step in the right direction) naturally limits the saving possible. There are 61 pages with no references.

In the *Gazzetta chimica italiana,* Volume 42, I., 316–416 (1912), nearly three quarters of a page could be saved. There are 61 pages with no references.

In the *Journal of the American Chemical Society,* Volume 34, 1631–1731 (1912), one page can be saved. There are 54 pages with no references. In the *Physical Review* an article always begins at the top of a page. The effect of this is that there is sufficient space at the end of most articles to print all the references, often on the basis of a line for each reference.

In the case of journals printed with two columns to a page, there is an incredible numbers of variations in the way in which numbers indicating references are used, as, for instance, giving numbers consecutively for the references in one article regardless of the number of columns used for the articles, or using numbers consecutively for one column regardless of the number of articles in that column, etc. These variations doubtless relieve the monotony of the work of editors, printers and proof-readers.

There is one great advantage in the method recommended here. It does away with "*loc. cit.,*" the abbreviation so easy to write, so saving of time and space in printing, so wasteful of time to one who has to go back an indefinite number of pages and read an indefinite number of references, in order to find where the authority for a given statement may be found. When many articles by one author, or many patents by one man are given, this "*loc. cit.*" may be so indefinite that it will be necessary to look through a number of the originals in order to get at the one desired. In a series of

articles, "*loc. cit.*" may refer to a reference published in a preceding article, sometimes to one in a preceding volume. In one case approaching the limit of misuse, the statement in the text reads, "Harvard[2] and Princeton[3] laboratories." The reference number 2 is to "*loc. cit.*" On looking at reference number 1 it is found that the word "Harvard" is not mentioned at all. In order to make sure that this "*loc. cit.*" did not refer to a reference in some preceding article, both the publications under number 1 would have to be noted and examined by any one unfamiliar with the fact that a man with a certain name, interested in a certain subject, was writing articles coming from Harvard in a particular year. This contingency will arise in some future time.

There are two classes of readers interested in the position of references. The reader who wishes only to see the date of a statement referred to in the text, or the name of the journal in which the statement was published, naturally finds it easier to look down at the foot of the page, instead of turning to the end. But the reader who wishes to look up an original article is willing to take this small trouble of turning to the end, especially when it saves time in the long run. Having had to read through articles, and look over references which ran in number into the hundreds of thousands, then look up thousands of the original articles from these references, I can speak from adequate experience of the positive value of the method recommended here, for it was always a pleasure and relief to come across the few articles using it.

Since there is a constant plea for saving of space in articles presented to scientific journals, a method of economy which will save from one half to one per cent. of the space now used, and at the same time increase the ease of looking up references and authorities, seems worthy of consideration.

Heyward Scudder

SCIENTIFIC BOOKS

Essays and Addresses. By the late James Campbell Brown, D.Sc. (Lond.), LL.D. (Abdn.), Professor of Chemistry in the University of Liverpool. With a Portrait and Twenty-two Illustrations. London, J. & A. Churchill. 1914. Pp. x + 208. Price $2.00 net.

A memorial volume is always of interest to the former students of a loved professor and to such this collection of essays and addresses by the late Dr. Campbell Brown will chiefly appeal; but from another standpoint this book is of interest not merely to chemists, but to all who come into touch with chemical industry, in that it presents the opinions of a discerning critic, expressed from time to time in a more or less popular way to audiences interested in the development and utilization of chemistry. This is particularly true at the present time when so many are turning their attention to the applications of chemistry to conditions of war.

Of the twelve addresses, three were delivered as chairman of the Liverpool Section of the Society of Chemical Industry, five before the Students' Chemical Society of University College, Liverpool, and two before joint meetings of the societies of the same college. The period covered in these addresses is 1886 to 1908, and many of the thoughts are equally applicable to the present time, especially those dealing with education.

It is interesting to read in the address on Technical Education delivered in 1886, Dr. Brown's strong plea for linking a sound early mental training with education of the hands, an idea which has been developed in this country along the line of the manual-training schools. Dr. Brown would, however, solve the problem along somewhat different lines. He would have workshops for different kinds of trades erected in a few well-chosen districts of a town, and require each scholar to spend a sixth day of every week in one or other of these shops, such day being counted as a part of regular school attendance. A single workshop would thus serve for a considerable number of graded schools, and the workshop day would be looked forward to as almost a holiday. He says: "By this system I do not think that the amount of ordinary school work would be lessened; but if it were, the decrease would

be very slight, and the reply to objections is, that some provision for training the hands and muscles to work is essential to an embryo workman, is beneficial to an embryo gentleman, and must be had at any sacrifice if we, as a nation, are to maintain our position in the face of other competing nations." This idea is in a few instances carried out in this country as regards higher technical education and with apparently good results, and would probably be better in our high schools than the present diversion of a part of our boys to manual training schools. But the greatest advantage would seem to be with the children in the grades.

Again Dr. Brown takes issue with the prevalent craze for a *practical* education in the sciences. "In the teaching of science it is a great mistake to aim *specially* at imparting a knowledge of facts which will be of use in after life. It is the desire to do this which has gone a great way in encouraging the multiplication of science subjects in schools. It would be far better to teach one science subject substantially and well than to teach a smattering of several. Every boy and girl, in whatever sphere of life, should be taught one science as a part of ordinary school training, but the mistake is too frequently made, both in science teaching and in ordinary school routine, of forgetting that it is the mental training and discipline, and not the storage of facts, that form the valuable feature of school work—the training of the understanding and the development of the reasoning faculties rather than the exercise of mnemonics." He considers that natural history, either vegetable or animal, is best adapted to the purpose of training the powers of observation and classification.

Again emphasizing the same idea in another address: "The use or object of education is not to impart a number of facts useful or otherwise, nor even to give useful hints and receipts that will enable the scholar to pursue some particular occupation; not to enable him to earn a living, or to earn a better living. That will follow, of course, as a secondary result of education, but its direct objects are of a far higher character. (1) To train the mind and its various powers, memory, reason, habit of precise observation, and arranging things which resemble each other and distinguishing things which differ. (2) Not so much to impart knowledge as to awaken the faculties and give the power of acquiring unlimited knowledge for oneself. (3) To cultivate the sense of the beautiful, not only of artistic beauty, which is of a material and physical kind, but a sense of intellectual order and beauty also. (4) And in all these ways to increase the happiness and the capacity for happiness of human beings." And then he adds: "If, in the course of education, some store of facts can be acquired at the same time, so far so good—for life is short—but that is not the first object of education."

To the young employees in the various works and mines of England he would send this message: "It is not merely by attending faithfully to their routine duties and performing them to the satisfaction of their employers that the Germans are beating them as clerks, beating them as inventors, beating them as workmen, beating them as manufacturers, beating them steadily in the markets of the world—for it is true that the Germans are doing all this—but because every German boy and girl, for more than two generations, has received a broad and thorough education, at institutions where every one is compelled, not merely to do routine lessons, but to think and train his intelligence; to learn principles and apply these principles in many practical ways; and unless the young Englishman engaged in industrial or commercial pursuits will set to work earnestly to broaden and deepen his education by systematic study after he has left the ordinary school, it is certain that the German, who is rapidly replacing the Englishman in some of the markets of the world, will replace the Englishman at home also. I do not doubt that the Englishman can, by his energy, beat the German as he has done in the past, but at present he is not doing so, and he is not even training himself in the right way for the struggle of life." "During my last visit to some of the industrial parts of Germany, I was very much struck, as every one would be, by the immense advance which was apparent as compared with a previous visit. Not only the employers, but the em-

ployed, are men of education. The managers and heads of departments, often those who are analogous to what we should call foremen in England, have a university education. All have spent many more years on their education than is usual in England."

In an address on "The Ethics of Chemical Manufacture," Dr. Brown would have the manufacturer remember that he has other and higher privileges, and that nobler duties devolve upon him than those which necessarily occupy the greater part of his thoughts during business hours. The satisfactory thing to contemplate in the development of the alkali industry is not the fortunes it made, nor even the employment it gave to thousands, but that it gave cheap and abundant means of cleansing self, raiment and dwelling to every family among the civilized nations of the earth. Balard is revered now not because he manufactured so many thousand kilos per week of salt from the sea water, but because, experimenting one day with the mother liquor, he observed for the first time some reddish-brown vapors, and followed them up, and became the discoverer of bromin. "Joule doubtless made excellent beer, because he is the sort of man who does everything well he undertakes; but his great work for which the world is indebted to him, and by which he will be remembered with gratitude throughout all time, was his determination of the mechanical equivalent of heat, whereby he laid the foundation of chemical dynamics and of the science of thermal chemistry, as well as brought about a revolution in an important branch of physics." The coal-tar dyestuff industry is not looked upon with much favor by Dr. Brown. "When one sees the glaring colors which are now flaunted before the public eye, often without any thought of harmony and with no consideration of appropriateness of position and surroundings —in advertising placards, house decoration, dress and so forth—one is sometimes tempted to ask whether the production of these new dyes has been a good thing for mankind, and whether, when our last mines are worked out and coal-tar dyes cease to be manufactured, the world will be any better for having had them, and whether the huge industry, which is at present flourishing, is not a waste of time, and of carbon compounds that would be better saved to keep us warm in winter—whether, at least, its highest merit is not that it affords a present means of livelihood to so many thousand workmen." The knowledge gained from the study of coal-tar products is the real justification of the "waste"; "this, rather than cheap alizarin, gaudy bills, brilliant shop windows and rainbow-colored dress, is the thing of which the coal-tar manufacturer should be proud."

A most interesting chapter is the address, "Reminiscences of August Wilhelm von Hofmann." Dr. Brown was a student in Hofmann's laboratory in the school of mines, and the story of the great master in lecture room and laboratory is most entertainingly told, with delightful personal touches. Here also we find most favorable views of German industry as he speaks of Hofmann's students and assistants working from nine in the morning till six at night, and often returning after dinner to work privately till a late hour. "That is the kind of work which tells. An eight-hours day may be all very well for working men who have no ambition and who are content with daily bread (and beer); but a gentleman has to work much harder."

There is included in the volume Dr. Brown's translation of the autobiographical fragment of Liebig, which originally appeared in the *Deutsche Rundschau* for January, 1891, and which is of great interest; and also a single original investigation, "Aquiculture: a Study of Deposits in Pipes and Other Channels Conveying Potable Water," read before the Institution of Civil Engineers. Altogether, the book as a whole is well worth perusal, both by chemists and by the general public.

J. L. H.

SCIENTIFIC JOURNALS AND ARTICLES

The July number (Vol. 16, No. 3) of the *Transactions of the American Mathematical Society* contains the following papers:

M. Fréchet: "Sur les fonctionnelles bilinéaires."
D. F. Barrow: "Oriented circles in space."
D. Buchanan: "A new isosceles triangle solution of the three-body problem."
L. P. Eisenhart: "Surfaces Ω and their transformations."
E. J. Wilczynski: "The general theory of congruences."
J. H. M. Wedderburn: "On matrices whose coefficients are functions of a single variable."
E. Kasner: "Conformal classification of analytic arcs or elements: Poincaré's local problem of conformal geometry."
D. R. Curtiss: "Extensions of Descartes' rule of signs connected with a problem suggested by Laguerre."
J. B. Shaw: "On parastrophic algebras."

THE concluding (July) number of Vol. 21 of the *Bulletin of the American Mathematical Society* contains: Report of the April meeting of the society in New York, by F. N. Cole; "An elementary double inequality for the roots of an algebraic equation having greatest absolute value," by G. D. Birkhoff; "Certain non-enumerable sets of infinite permutations," by A. B. Frizell; "George William Hill, 1838–1914," by E. W. Brown; Review of Dickson's Linear Algebras, by W. C. Graustein; "Shorter Notices": Poincaré's Wissenschaft und Methode, by J. B. Shaw; Martin's Text-book of Mechanics, Vol. 5, by F. L. Griffin; "Notes"; "New Publications"; Twenty-fourth Annual List of Published Papers; Index of Volume 21.

SPECIAL ARTICLES

THE THEORY OF MAGNETIZATION BY ROTATION

THE experiment which I described in a recent number of this journal may be considered as a modification of an experiment made long ago by Maxwell,[1] who appears to have been the first to conceive the idea that a magnet should behave like a gyrostat if its Ampèreian currents are actually *material,* as modern theory assumes. In Maxwell's experiment an electromagnet, mounted in a frame in such a way as to be free to move about a horizontal line through its center of mass and perpendicular to its magnetic axis, was rotated at high speed about a vertical line, and optical observations were made to see whether the angle α between the vertical and the magnetic axis was altered as the speed increased from zero, stability being secured by properly adjusting the moments of inertia. No change in α was observed, but only rough experiments were possible.

In my experiment the electromagnet is replaced by each of the countless multitude of molecular magnets of which the iron rod is constituted, and the total change in the orientation of all the magnets with reference to the axis of rotation of the rod is determined magnetically instead of optically.

In the complete paper it is shown that the angular momentum M of the simplest type of molecular magnet possible, constituted of a negative electron with mass m and charge e revolving with angular velocity ω in a circular orbit about a positive nucleus with charge $-e$ at rest, is related to the magnetic moment μ by the equation

$$M = 2(m/e)\mu. \qquad (1)$$

If now the rod of which the molecular magnet is a part is set into rotation about its axis AB, with angular velocity Ω, the angle α between the vector M and AB will *decrease,* just as in the case of a gyroscope, until the torque T' on the system brought into existence by this displacement is just equal to the rate of increase of its total angular momentum in the steady state when kinetic equilibrium has been reached and the vector M is tracing out a conical surface with constant semi-angle α and angular velocity Ω. The effect in this steady state is exactly the same as if the rod were at rest and the molecular magnet were acted upon by a torque $T'' = -T'$ due to an extraneous magnetic field of strength H, where H is the intrinsic magnetic intensity of rotation. The complete expression for the torque T'' is known (and can readily be shown from first principles) to be

$$T'' = -T' = -M\Omega \sin\alpha - B\Omega^2 \sin\alpha \cos\alpha, \qquad (2)$$

where B denotes the difference between the

[1] *Elec. and Mag.,* § 575.

two principal moments of inertia of the orbital system. In the case under consideration $B = M/2\omega$. Eliminating B and M from (2) we get

$$T'' = -\mu \sin\alpha \cdot 2\frac{m}{e}\left(1+\frac{1}{2}\frac{\Omega}{\omega}\cos\alpha\right).^2 \quad (3)$$

If we divide this expression by $-\mu \sin\alpha$ we shall, as in the case of an ordinary magnetic field, get the intensity sought, viz.,

$$H = 2\frac{m}{e}\Omega\left(1+\frac{1}{2}\frac{\Omega}{\omega}\cos\alpha\right).^3 \quad (4)$$

The magnitudes of Ω experimentally attainable are so small in comparison with ω that the second term is always negligible.

If we assume that e/m has the value (-1.77×10^7) ordinarily accepted for the negative electron in slow motion, and put $\Omega = 2\pi n$ where n is the speed of the rod in revolutions per second, we get for the intensity per unit speed

$$H/n = -7.1 \times 10^{-7} \frac{\text{gauss}}{\text{r.p.s}}. \quad (5)$$

This is the *maximum* magnitude possible; if some or all of the positive ions also have orbital motion, H will be smaller in magnitude than indicated by (4), but will still be proportional to Ω. The experimental value of H/n was, within the accidental error, one half that given by (5).

S. J. Barnett
The Ohio State University

The Transmission of Potato Mosaic through the Tuber

Mosaic of the potato is very prevalent in Bermuda on the Bliss Triumph and is the cause of serious losses to the growers, as the yield of affected plants is reduced from 10 to 75 per cent., and often a field will have a large proportion of plants with this disease.

An inspection made in July, 1914, of the fields on Long Island in which stock was being grown for shipment to Bermuda for seed purposes showed the almost general presence of mosaic on the Bliss Triumph. The same condition existed in many fields of Bliss Triumph in Maine, where the stock for Long Island is obtained. These general facts strongly indicated that the mosaic of potatoes was transmitted by the tubers, in the first case from Maine to Long Island and in the second generation from Long Island to Bermuda.

There was, however, no evidence in the literature on potato growing to support this view. Dr. W. A. Orton, in Bulletin 64 of the United States Department of Agriculture, on "Potato Wilt Leaf Roll and Allied Diseases," writes, "it is not improbable that mosaic is transmitted by the tubers" adding, however, that no experiments had been undertaken that had conclusively proved this. Experiments were consequently conducted at the agricultural station in Bermuda with a view to securing definite information on this point.

Through the courtesy of Drs. I. E. Melhus and L. O. Kunkel, of the Bureau of Plant Industry of Washington, tubers from selected hills of healthy and mosaic parents were obtained from a field at Van Buren, Maine, that was visited by the writer in September, 1914.

The tubers obtained from Van Buren were planted in Bermuda in November, 1914, in duplicate rows, and the result showed in a striking manner in January, 1915, that the mosaic of potatoes is transmitted through the planting of tubers from mosaic parents:

No. of Plants	Tubes Selected from	Percentage of Mosaic Plants
A. 200	Healthy parents	nil (4 or 5 doubtful)
B. 200	Stock on the market	80
C. 200	Mosaic parents	100

The yield from the plants affected with mosaic was less than half that of the healthy stock.

Mosaic of the potato is undoubtedly one of the serious potato problems that have escaped the notice of the practical farmer and that have until recently received little attention from scientific workers. To growers of the

[2] This equation also follows immediately from Maxwell's equation by putting in the conditions here assumed.

[3] The first term of this equation has been given previously, by Einstein and de Haas, but was obtained incorrectly, equations for a *molar* magnet instead of a *molecular* magnet being employed.

Bliss Triumph in particular it is a matter of considerable importance, and the result of these experiments shows that the disease can be readily controlled by field selection of the stock intended for planting next season.

It is believed that the experiments reported here are the first that have definitely shown that potato mosaic is transmitted through the tubers. A series of photographs have been taken which show the difference between the progeny of healthy and mosaic parents and it is intended to publish a fuller account of the experiments at an early date.

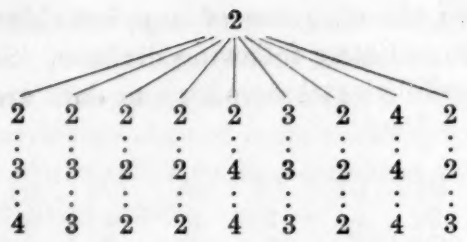
E. J. WORTLEY

PAGET EAST, BERMUDA

THE INHERITANCE OF EXTRA CONTRACTILE VACUOLES IN AN UNUSUAL RACE OF PARAMŒCIUM CAUDATUM

IN the early part of January, while examining paramœcia from a general culture maintained for laboratory purposes, it was noticed that one of the individuals had three contractile vacuoles. Further investigation showed this condition to be the rule rather than the exception, and a number of single individuals, each showing three vacuoles, were isolated with which to start pure-line cultures.

The descendants of these single individuals showed wide variation in vacuole number. In one pure line several weeks after it started 8.6 per cent. of the individuals had two vacuoles, 65.7 per cent. had three and 25.7 per cent. had four. In other cultures numbers as high as five and even six vacuoles appeared rarely. Immediately after division the average number is lower; in some very rapidly dividing cultures as many as 59.1 per cent. of the individuals may have only two vacuoles, though this return to the normal number apparently is only temporary, as the same individuals may later develop a third or even a fourth vacuole. This condition is represented by the following experiment in which an individual showing two vacuoles was allowed to pass through several divisions and then three observations were taken on each of the descendants at intervals of from four to five hours.



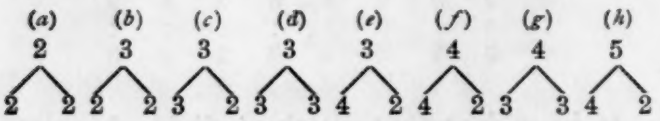
It is evident that all the individuals starting with two vacuoles did not later acquire a third, nor did all those having three to begin with have four before division. Those paramœcia possessing but two vacuoles, although they may divide without having shown an increase in the number of vacuoles, have not lost the power of producing extra contractile organs though several generations may be passed through before they appear.

In this multi-contractile vacuoled race the extra vacuoles are with very few exceptions located in the posterior half of the *Paramœcium*. In cases where three are present, two are found in the posterior half and one in the anterior. Only two cases have been observed in which the reverse condition was true. When four vacuoles exist the arrangement is generally three in the posterior and one in the anterior end, although there may be two in each end.

No exact observations have been made as yet on the formation of the new vacuoles. Very small vacuoles have been seen which have apparently just formed and which are usually at some distance from the others. These increase fairly rapidly in size until they reach the maximum. During the growth of some new vacuole, the one nearest to it loses temporarily its regular contraction. When the new vacuole has reached full size it beats spasmodically a few times before it settles down to its regular rhythm. Shortly the old and the new vacuoles become accustomed to the new conditions and the usual rhythmic beat begins. This is not always the case, as vacuoles have been observed to form without affecting the rhythmic beat of the older vacuoles near it in the slightest.

It is practically impossible at present to predict with certainty what number of contractile

vacuoles the offspring of any individual may have immediately following division. Some of the possibilities observed up to date are illustrated below.



Apparently at division two vacuoles are added in the normal way as a rule (one to the posterior end and one to the anterior). This is not invariable as is evidenced by (*b*), (*d*) and (*h*). As stated above, although a *Paramœcium* of this race may not show an increase of vacuole number up to the time of division it has not lost the power to produce extra vacuoles. In cultures started with two-vacuoled forms, individuals have been found showing three and four vacuoles. The most common distribution at division in the three-vacuoled individuals is three vacuoles to the posterior part and two to the anterior half. There is no fixed order in the distribution of the vacuoles at division and no definite time at which the extra contractile vacuoles appear in the life cycle of the individual. The only definite statement that may be made of this race is that it has a tendency to more than two contractile vacuoles.

The race is strong and healthy and some of the individuals are very large. There is no invariable relation between the size of the animal and the number of vacuoles. A small animal may have more than a larger one. Since the race has been under observation (about four months) there have been two periods of extremely rapid division, the rate rising to five divisions in twenty-four hours and continuing at this rate for six or seven days. During these periods no individuals with four or five vacuoles were seen and the two-vacuoled forms seldom passed into the three-vacuoled condition before division, although they did not lose the power of returning to the higher numbered vacuoled state when the division rate slowed down.

The original laboratory culture was started by Dr. Merkle Jacobs in the fall of 1914. The paramœcia he had been using in high temperature experiments were thrown into a battery jar of hay infusion. So far as is known, the animals used for these experiments had the normal number of contractile vacuoles, though there is a possibility that the higher number were already present. The irregularity of the behavior of the extra contractile vacuoles would seem to indicate that they were recently acquired structures that had not become as yet firmly established as a part of the organism. There has also been some slight indication lately, observed by both Dr. Jacobs and myself, of a tendency to settle down into a more regular order with three as the maximum number of vacuoles.

Since *Paramœcium caudatum* has been the most widely studied protozoan and no cases have been reported where extra contractile vacuoles have been found, considering the origin of the culture, there is some excuse for suggesting that this potentiality for extra vacuoles may have been acquired. The great irregularity of the time of formation of these vacuoles along with the tendency to become more regular, as stated above, would seem to bear this hypothesis out. The paramœcia of the original culture had been subjected to a temperature of at least 40° Centigrade and it might be supposed that the extra vacuoles were formed under the stress of the unusual environment. Furthermore, Dr. Jacobs has found that this race is abnormally resistant to high temperatures. Under the conditions where ordinary race of paramœcia are killed at temperatures of 40° Centigrade to 42° the race in question will survive an exposure to 44° or more.

A more extended account will be published shortly giving more of the details and methods. It is intended later to attempt to develop a new multi-vacuoled race by subjecting normal individuals to high temperatures in order to test the hypothesis suggested above.

Dr. Jacobs has carried on experiments with the same race of *Paramœcium* which have confirmed those recorded here.

Robert T. Hance
Zoological Laboratory,
University of Pennsylvania

OBSERVATIONS ON AZOTOBACTER

THE group of bacteria having the capacity of using free atmospheric nitrogen in their metabolic processes consists of three general types: (1) Those associated with the nodule formation of legumes (*Ps. radicicola*); (2) large bacilli which produce spores located in the center of the cell, causing an increased diameter of the cell at that point (*Clostridium pasteraneum*); and (3) a form displaying considerable variation in size and shape, which, according to original descriptions, is without endospores (*Azotobacter* sp.).

The discovery of the extraordinary ability of these organisms to secure a supply of nitrogen from the air brought them into immediate prominence as objects of systematic study. The nitrogen-assimilating property was first detected in the *radicicola*, and hence the earlier studies were concentrated upon this organism. After the isolation of the other two forms, however, they assumed quite as much importance as had attached to the legume organism. In fact, recently more attention has been given to the former than to the latter. This has been especially true of the *Azotobacter*. The *Clostridium* has never been so inviting as either of the others; perhaps because of its morphological uniformity. Then, too, it appears to have less nitrogen-gathering power.

At various times, while working with other phases of the problem of soil bacteriology, I have attempted to isolate the *Azotobacter* from our local soils and study it rather intensively. On several occasions these efforts have resulted in the securing of pure cultures of the bacillus. So far as the observations went, however, no peculiarities were presented which had not previously been noted by other investigators. During the year 1913 a culture was secured which showed some striking qualities. These attracted immediate attention and led to an extensive study.

Soon after the isolation of *Azotobacter croococcum* by Beyerinck, other investigators gave descriptions of five or six types of *Azotobacter* which they regarded as distinct species. One of these forms was given the name *Azotobacter vinelandii* by Dr. J. G. Lipman, who isolated and described it. The chief basis upon which this species was established is the quality of pigment production. In this case the color of the pigment is a distinct yellow, as contrasted with the heavy brown pigment of *A. croococcum*.

From the outset the bacillus under consideration here has been regarded as a variety of *A. vinelandii*. In many respects, however, our type differs so markedly from the original description of *A. vinelandii* as to create considerable doubt as to the identity of the species. Nevertheless, I am still disposed to regard it as a mere variety within this group. As a matter of fact, the recent work of Prazmowski and others tends to eliminate the various species of this organism and regard them all as one species consisting of several varieties. My own observations lead me to favor this contention. The pigment color of the culture in my laboratory shows considerable variation, ranging from yellow to brown. This seems to depend largely upon the medium used.

The following comparison will show the chief points in which our type varies from the species description:

Features Considered	Original Description	Observation Made in the Present Investigation
Mannite agar plates	Colonies 4 mm. in 4 days.	Colonies 6–8 mm. in 4 days.
Mannite agar plates	Colonies whitish.	Colonies yellow.
Glucose solution	Surface film.	No surface film.
Mannite solution	Yellow pigment.	No pigment.
Glucose agar stab	White.	Yellow.
Mannite agar stab	White.	Yellow.
Potato	Dirty white.	Pink, young; yellow, old.
Spore formation	Absent.	Present.
Thermal death point	80°–85° C., 5 min.	90°–95° C., 5 min.

Probably nothing else in this comparison is so significant as the disagreement in regard to the spore production and the corresponding high thermal death point of our cultures.

Beyerinck, in his original observations on *Azotobacter croococcum,* failed to detect the presence of spores. Nevertheless, in 1911 E. Mencl[1] demonstrated their presence in this species. It was recognized early in the study of *Azotobacter* that they are very resistant to drying and other adverse conditions, which fact aroused the suspicion that spores are produced. The morphological irregularity and change of form under different cultural conditions obscured the true nature of the case until the date mentioned above. If all *Azotobacter* are to be regarded as one species, my observation of spores is, of course, only a repetition of observations made recently by several investigators.

In the cultures with which I worked the organisms attained very great size, and showed in many cases a striking resemblance to budding, similar to that observed in yeast cells. At such times the cell is well filled with refractive bodies which do not stain readily with the analine dyes. Such bodies have generally been looked upon as fat, but the fact that by special effort they can be stained with methylene blue led to some doubt as to their fatty nature. Efforts were made to stain these bodies with the ordinary fat stains, such as Soudan 3 and Sharlac red, but the results were all negative. *Azotobacter* were then grown on potato in sufficient quantities to secure a sample large enough for ether extraction. Potatoes were cut in thin slices and sterilized in petri dishes, and then inoculated. The growth was excellent, and a considerable mass of this was secured by scraping from the surface.

The material thus secured was placed in a separatory funnel and treated with pure ether for twenty-four hours without heat. The funnel was shaken several times during the extraction and then allowed to stand for sedimentation. Several cubic centimeters of the clear solution were then drawn into a weighed platinum dish and evaporated to dryness. It was found that a sediment detectible by weight was left in the dish. This may have been a mixture of fats, gums and resins, or possibly any one of these.

The funnel in which the extraction was made was set aside with the residue of the bacterial mass and a thin layer of ether which overlay the mass. No attention was given to it for about two weeks. When it was examined there was a brownish layer on the surface of the ether. This layer gave one the impression that it consisted of a bacterial growth. Ether has, of course, been regarded as a disinfectant, and although it has never been thought of as having great germicidal power, yet in a high concentration one would certainly be surprised if it should not be found sufficient to inhibit all growth.

Cover-glass preparations were made from the scum on the ether in the funnel referred to, and it was found to contain large numbers of bacteria. These might have come from the original mass from the potato and been dead at the time they were taken from the ether. At the same time that the microscopic preparations were made, however, inoculations on agar were placed in the thermostat for incubation. At the end of twenty-four hours, when the agar tubes were examined, they were found to have a good growth on them, stains from which showed that it consisted of *Azotobacter.* It was evident, therefore, that practically pure ether had not killed this organism. It was also made reasonably certain by this observation that the scum on the ether in the funnel consisted of living *Azotobacter.*

It remained to be shown that the organisms were actually multiplying in the solution. This was accomplished in the following way: Small Ehrlenmeyer flasks were supplied with sufficient Squibb's pure ether to make a thin layer on the bottom of the flask and a small particle of the potato culture was introduced into them. These were set aside at room temperature for development, and at the end of a week or ten days a decided growth could be detected.

Another method that was employed to test

[1] *Arch. Protistenk.,* 22 (1911), No. 1, pp. 1–18.

the ability of *Azotobacter* to grow in the presence of ether consisted in placing cylinders of potato in test tubes having plugs of absorbent cotton in the bottom saturated with pure ether. The slant of the potato was inoculated with the organism and incubated at room temperature. These cultures almost invariably had a growth at the end of from eight to ten days. The growth on potato had a decided stringiness. Stains from such a mass revealed a dense zooglea.

In the case of the cultures in liquid ether the only apparent source of carbon is the ether itself, and the bacteria are therefore under the necessity of using this in their metabolic processes. When the flasks containing old cultures were examined from day to day it was possible to detect what appeared to be the odor of alcohol and ether alternately. The successive hydration of ether and dehydration of alcohol would account for this phenomenon, but the probability of bacteria being able to induce these changes is certainly extremely remote. The oxidation of ether has recently been shown to result in the formation of aldehyde and acetic acid. Any attempt, however, to explain the nature of the process taking place in the flasks would be mere speculation, since the matter has not been experimentally investigated.

MAURICE MULVANIA
KNOXVILLE, TENN.

THE ROYAL SOCIETY OF CANADA

THE thirty-fourth annual meeting of the Royal Society of Canada was held in Ottawa, May 24 to May 27, inclusive, under the presidency of Sir Adolphe B. Routhier. The attendance was one of the largest in the history of the society, founded in 1882 by the Marquis of Lorne, at the time governor general of Canada. The four sections into which this national society is divided met under their respective presidents: Section I., French literature, history, archeology, etc. (in French); Section II., English literature, history, archeology, etc. In this section the following papers are of scientific value: "Some Notes upon the Discovery of a Prehistoric Human Skeleton in British Columbia," by Charles Hill-Tout. This skeleton came "from Undisturbed Strata in the white silts of the Interior Plateau" of that province, near Kamloops, and places the prehistoric history of man in western Canada back to the glacial period. "Social Organization of the West Coast Tribes," by Professor Adam Shortt, C.M.G., also forms an interesting study.

Section III., dealing with the mathematical, physical and chemical sciences, comprises numerous papers of special interest and value.

Professor R. F. Ruttan (McGill University), discussed "The Chemistry of Adipocere."

This paper deals with the changes in animal fats, as the result of prolonged action of moisture with the exclusion of air. The adipocere studied was found in a recent Post-Tertiary deposit of wet soil near Ormstown, Quebec. The material had the general character and appearance of soft chalk to the touch.

Another paper by Dr. Ruttan was entitled "Glycol Esters of the Fat Acids," pointing out a new series of fats formed by the replacement of ethylene glycol for the glycerol of ordinary fats.

Dr. Harding presented the result of investigations by him and Messrs. A. R. Maclean and F. H. S. Warneford, on "The Ninhydrin Reaction," being a critical study of this reaction for alpha amine acids, its quantitative relations and the chemistry of the color produced.

Then followed numerous contributions in the physical and mathematical sciences, and in astronomy, spectroscopy, electricity, metallurgy, meteorology, etc. These include:

A Comparison of Radium Standard Solutions: J. MORRAN. Presented by PROFESSOR A. S. EVE, F.R.S.C.

Notes on the Penetrating Radiation from the Earth: PROFESSOR A. S. EVE, F.R.S.C.

Some Experiments on the Thermionic Current: PROFESSOR A. S. EVE, F.R.S.C.

The Solar Rotation: DR. J. S. PLASKETT, F.R.S.C.

This paper gives the values of the spectroscopic determination of the Solar Rotation from plates made at Ottawa in the years 1911, 1912, 1913. A summary of the rotation values at different latitudes, the formula connecting the variation of velocity with latitude and discussions of other important aspects of the question was given.

The Determination of the Distance of the Nearer Stars from their Proper Motions and Radial Velocities: REYNOLD K. YOUNG, Ph.D. Presented by DR. J. S. PLASKETT, F.R.S.C.

From 167 stars whose parallax, radial velocity and proper motion are known, the direction and magnitude of the solar motion was found. The mean distance of the stars was evaluated by a comparison of the mean radial velocity and mean

proper motion at right angles to the direction of the sun's way, also by a comparison of the parallactic motion with the solar velocity. While the results of these two methods differ considerably their mean agrees with the observed parallax.

On the Electrical Conductivity of Air Confined in an Ice Vessel: Professor J. C. McLennan, F.R.S.C., and Mr. Harold G. Murray.

On the Residual Ionization in Gases over the Sea and on the Surface of Lake Ontario: Professor J. C. McLennan, F.R.S.C., and Mr. C. L. Treleaven, B.A.

On the Absorption Spectra of Zinc and other Metallic Vapors: Professor J. C. McLennan, F.R.S.C., and Mr. Evan Edwards, B.Sc.

Note on the Ultra-Violet Spark Spectrum of Silicon: Professor J. C. McLennan, F.R.S.C., and Mr. Evan Edwards, B.Sc.

On the Ionization Potentials of Mercury Zinc and Cadmium Vapors and their Single Line Spectra: Professor J. C. McLennan, F.R.S.C., and Mr. J. P. Henderson, B.A.

Application of Wilson's Method to a Study of the Ionization Paths of Alpha Rays in Hydrogen: Professor J. C. McLennan, F.R.S.C., and Mr. H. N. Mercer, B.Sc.

On the Delta Radiation from Zinc freed from Gases under Bombardment by Alpha Rays: Professor J. C. McLennan, F.R.S.C., and Mr. C. G. Found, B.A.

On the Infra-red Spectrum of the Mercury Arc: Professor J. C. McLennan, F.R.S.C., and Mr. R. C. Dearle, B.A.

On the Resolution of Spectral Lines by an Electric Field: Professor J. C. McLennan, F.R.S.C., and Mr. K. H. Kingdon, B.A.

On the Study of Röntgen Ray Spectra: Professor J. C. McLennan, F.R.S.C., and Mr. A. R. McLeod, M.A., and Mr. R. L. Lewis, B.Sc.

The Crushing Strength of Ice: Professor H. T. Barnes, F.R.S.C., and Mr. H. M. Mackay.

Experiments on large blocks of ice were made on the Emery testing machine. The results agree with those presented last year.

The Effect of Strain on the Thermal Expansion of Quartz: Professor H. T. Barnes, F.R.S.C.

Quartz rods were put under tension up to their breaking point and the coefficient of expansion measured between 0° and 100° C. No effect was observed.

Secondary Cathode Rays from Gases: A. Norman Shaw, D.Sc. Presented by Professor H. T. Barnes, F.R.S.C.

On Osmosis in Soils: C. J. Lynde, and V. V. Dupré. Presented by Professor H. T. Barnes, F.R.S.C.

This paper gives the results of experiments made to determine whether or not the pressures observed are due to osmosis.

On the Flow of Air in Two-dimensional Channels with Special Reference to the Stability of Stream Line Motion: Louis Vessot King, M.A. (Cantab.).

An account is given of experiments carried out with the author's hot-wire anemometer on the distribution of velocity in the flow of air between parallel planes. The observations were taken with a view of obtaining some light on the conditions which determine the breakdown of stream-line motion into turbulent flow.

On the Distribution of Air Velocity in the Neighborhood of a Rotating Cylinder: A. Gray, B.Sc., and Louis Vessot King, M.A. (Cantab.).

On the Calculation of the Self and Mutual Induction of Coaxial Cylindrical Coils: Louis Vessot King, M.A. (Cantab.).

I. A new method of deriving the formulæ for the self and mutual induction of coaxial cylindrical coils is obtained by reducing the problem to one of calculating a simple case of gravitational attraction.

II. By the application of Gauss's theorem of the Arithmetico-Geometrical mean, the calculation of the elliptic integrals which occur in the formulæ for self and mutual induction of coaxial single layer coils is made possible to a high degree of accuracy with comparatively little labor of computation and without the use of Legendre's tables.

III. Simple quadrature and graphical methods for the approximate calculation of the constants are also described.

Geometrical Configurations that lead to the Solution of a System of Partial Differential Equations of the Second Order: Chas. T. Sullivan. Presented by Dr. J. Harkness, F.R.S.C.

Progress on the 72-inch Reflecting Telescope: Dr. J. S. Plaskett, F.R.S.C.

The present condition of the grinding and polishing of the mirror and of the construction of the mounting will be described and illustrated by lantern slides.

Liquid Chlorine as a Solvent: Cryoscopic Measurements at Low Temperatures: P. Waentig and D. McIntosh, F.R.S.C.

Determinations of the lowering of the freezing point of chlorine by various solutes were made. Toluol, chloroform and various substances forming oxonium compounds such as ether, gave normal results; bodies containing the hydroxyl group were polymerized.

The Preparation of Metallic Vanadium: R. EDSON and D. MCINTOSH, F.R.S.C.

Vanadium was deposited on a heated wire from an atmosphere of a volatile vanadium compound and hydrogen.

Bromocamphor Sulphonic Acid and Oxonium Compounds: D. MCINTOSH, F.R.S.C.

An account of an unsuccessful attempt to prepare oxonium compounds.

The Viscosity of Ethyl Ether in the Neighborhood of the Critical Point: A. L. CLARK, B.Sc., Ph.D.

A Self-recording Instrument for Measuring Earth Temperatures: JOHN PATTERSON, M.A. (Cantab). Presented by R. F. STUPART, F.R.S.C.

The instrument consists of a Thread Recorder Galvanometer and a set of thermo couples connected through a special commutator to the galvanometer. A record is obtained of the temperature at the surface and at a depth of six inches twice every hour; below six inches the record is obtained once every hour at each depth.

On the Diurnal Changes in Magnetic Horizontal Force at Agincourt, 1902–1912: W. E. W. JACKSON, M.A. Presented by R. F. STUPART, F.R.S.C.

The mean diurnal inequality for each month of the year is treated by harmonic analysis and the seasonal variations brought out, and a comparison made with seasonal variations at Kew. Finally the abnormalities in the monthly diurnal ranges during years of maximum and minimum sun spots is shown, and also the variations in the seasonal values of the Fourier coefficient with the sun spots.

Comparison of the Callendar Sunshine Receiver and the Angstrom Pyrheliometer: JOHN PATTERSON, M.A. (Cantab). Presented by R. F. STUPART, F.R.S.C.

The comparison made by the author in 1912 showed that there was a very large difference between the two instruments, and the comparison has been continued in order to find out the cause of the difference.

The Diffusion of Oxygen Through Silver: F. M. G. JOHNSON, Ph.D., F.R.S.C.

Waves in a Jet of Water: MR. OTTO MAAS. Presented by D. MCINTOSH, Ph.D., F.R.S.C.

In Section IV. (Geological and Biological Sciences), Dr. Buller, of the University of Manitoba, Winnipeg, delivered the presidential address and discussed "Micheli and the Discovery of Reproduction in Fungi." The other papers included:

A Contribution to a Knowledge of Canadian Ticks: DR. C. GORDON HEWITT, F.R.S.C.

The economic importance of many of the native species of ticks in North America as responsible agents in causing certain known and obscure diseases or pathological conditions in man and domestic animals renders a knowledge of the occurrence and distribution of the species occurring in Canada very desirable. The present paper brings together in an accessible form information collected by the author and others.

I. *A Comparison of Spore-discharge in the Uredineæ and the Hymenomycetes:* A. H. REGINALD BULLER, D.Sc., F.R.S.C.

A minute study of the discharge of sporidia from the promycelium of a rust fungus and from the basidiospores of Agarics has provided evidence that the processes of discharge in the Uredineæ and Hymenomycetes are identical in nature. (Lantern slides.)

II. *The Movements of Spirogyra:* A. H. REGINALD BULLER, D.Sc., F.R.S.C.

The free ends of *Spirogyra* filaments execute fairly rapid bending movements, the result of which is that the filaments become twined around one another so as to form wisps. The filaments in each wisp lie more or less parallel to one another. The parallel situation of the filaments in any wisp eventually facilitates scalariform conjugation. The movements therefore have a biological significance. (Lantern slides.)

On the Taxonomic Value of the Placenta: DR. ARTHUR WILLEY, F.R.S.C.

The paper discusses the relations of the various forms of placenta in the light of recent advances in mammalian embryology, with special reference to the gestation of the Canadian beaver.

Comorocystitis punctatus Billings: SIR JAMES GRANT, K.C.M.G., F.R.S.C.

A Cystidian from Ottawa.

The Cretaceous Sea in Alberta: D. B. DOWLING, F.R.S.C.

A fairly extended description of the formations underlying the plains is available in the several reports that have been made by various observers. The beds composing these formations have been examined in many localities and the animal re-

mains that have been found indicate the character of the medium of distribution. Some of the deposits suggest the presence for a time of a wide shallow muddy sea. Others are evidently near-shore deposits with remains of brackish-water or even fresh-water life. The final retreat of the sea from the central part of the continent is marked by a series of brackish-water deposits covered by material that has been distributed by fresh-water streams or in lakes.

In the western part of Alberta there are indications that the western margin of the marine invasion can be located and that there was at various periods a distinct narrowing of the sea so that land areas appeared which occupied portions of the present area of western Alberta. An attempt at defining the western margin of the Cretaceous sea at successive stages is made in the paper. This shows graphically in the retreat of the sea the inauguration of a period of unrest which later culminated in the elevation of this part far above the sea and finally in the formation of the Rocky Mountains.

Notes on some hitherto Unrecorded Occurrences in British Columbia, of Uncommon Minerals, Collected by the late W. J. Sutton, of Victoria: R. W. Brock, F.R.S.C.

The late W. J. Sutton, of Victoria, made an extensive private collection of rocks and minerals. In it are a number of specimens of minerals from British Columbia, whose occurrences have not as yet been brought to the attention of the scientific world. Mr. Sutton, no doubt, would have described these in detail; the writer can only mention such as he noticed, but places them before the society in order that they may be credited to this earnest and enthusiastic mineralogist and geologist.

A British Columbia Example of the Contact Metamorphism of a Granite Rock to a Garnet: R. W. Brock, F.R.S.C.

Contact metamorphism is a common phenomenon in British Columbia. Limestone, here as elsewhere, is the rock which most frequently shows pronounced effects of this process. In the Boundary Creek District, while this is also the case, other rocks have been affected in like manner, though the late S. F. Emmons and other authorities who visited the Boundary Creek District have expressed the opinion that such alteration was confined to the limestones. An unequivocable instance of the alteration of granodiorite occurs on Pass Creek, as mentioned by the writer in the Summary Report of the Geological Survey for 1902. Although other instances of somewhat similar occurrences are now generally recognized and accepted, this occurrence is deemed worthy of a more extended description than it received in the Summary Report above mentioned, as being one of the most definite and striking examples of such metamorphosis yet found.

The Upper Limit of Temperature Compatible with Life in the Frog: A. T. Cameron and T. I. Brownlee. Presented by Dr. Swale Vincent, F.R.S.C.

Frogs (*R. pipiens*) will endure an (internal) temperature of 28° C. for several hours. A temperature of 30° C. is fatal in six hours. Death is apparently produced through some coordinating mechanisms in the central nervous system, since the individual tissues (striped muscle, heart, peripheral nerve and brain and cord) survive, and are only killed by distinctly higher temperatures. The results are therefore in line with those found by the authors of the lower limit of temperature compatible with life.

On an Accumulation of Gas in the Tissues of the Frog as a Result of Prolonged Submersion in Water: A. T. Cameron and T. I. Brownlee. Presented by Dr. Swale Vincent, F.R.S.C.

Frogs (*R. pipiens*) submerged completely in running water, but free to move, survive, on the average seven days, though individuals may survive three weeks. About two days before death they commence to swell, and rapidly become so buoyant that they can not any longer dive. The cause of death appears to be connected with this distension, which is caused by gas, distributed throughout the body and all tissues. The gas is almost pure nitrogen, and may amount in volume to 15 c.c. or over.

On the Relative Importance to Life of the Cortex and the Medulla of the Adrenal Bodies: T. D. Wheeler and Swale Vincent, F.R.S.C.

As the result of a long series of experiments upon dogs, cats and rabbits, in which the medulla was removed as completely as possible (without inflicting more than an unavoidable damage to the cortex), it would appear that the cortex is the part which is essential to life, and that the chromaphil tissue constituting the medulla can be entirely removed without any serious results.

A Study of some Organisms which Produce Black Fields on Æsculin-bilesalt Media: F. C. Harrison, D.Sc., F.R.S.C.

In the summer of 1913 more than 4,000 Æsculin-bilesalt agar plates were made from samples of

milk obtained from more than a thousand different dealers or farmers in the province of Quebec.

Seven hundred colonies from these plates were selected for further study, and we found 11 organisms which developed black fields in less than 48 hours on æsculin-bilesalt media at blood heat, and which did not belong to the colon-aerogenes group. These organisms came from the vicinity of Huntingdon, Quebec, but could not be isolated from milk obtained from this district the following spring.

By keeping the æsculin-bilesalt agar plates at room temperature for at least five days, more exceptions appeared, seven of which were carefully studied.

The Harrison-Barlow Nitrocultures and their Commercial Application: F. C. HARRISON, D.Sc., F.R.S.C.

At the meeting of the Royal Society held in May, 1906, Harrison and Barlow read a paper on the "Nodule Organism of the Leguminosæ—Its Isolation, Cultivation, Identification and Commercial Application." Since that date large numbers of the so-called nitro-cultures prepared according to the directions given in the above mentioned paper were distributed to farmers in Canada and the United States. This paper gives a short account of the commercial application of these nitro-cultures between 1906 and 1914.

The Diatoms of the Coast of Vancouver Island, B. C.: DR. L. W. BAILEY, F.R.S.C., and DR. A. H. MACKAY, F.R.S.C.

So far as known to the writers of this paper no publications relating to the diatoms of the Pacific Coast of Canada have as yet been made. The establishment of one of the stations of the biological board of Canada at Nanaimo, B. C., having made it possible to obtain materials for the study of these organisms, some of the results of that study are here presented in preliminary form.

The total number of species so far identified is over 250, of which a list, with diagnostic measurements, is given. Of these several are believed to be new. The characteristics of the phytoplankton are distinctly indicated and comparisons are drawn between those of the Pacific and Atlantic coasts, as well as those of the North Sea and the Antarctic, to the latter of which the Vancouver collections bear interesting resemblances.

Metallogenetic Epochs in the Pre-Cambrian of Ontario: WILLET G. MILLER, F.R.S.C., and CYRIL W. KNIGHT.

During the vast period represented by the pre-Cambrian rocks of Ontario ore deposits were formed at various epochs. Knowledge of the pre-Cambrian gained during the last decade furnishes a means of correlating these ore deposits as regards their age and genetic relations.

Modes of Occurrence of some Gold-bearing Veins in the Pre-Cambrian Rocks of Canada: J. B. TYRRELL, F.R.S.C.

For nearly fifty years gold has been known to occur in mineral veins in the pre-Cambrian rocks of Central Canada. While the great majority of these occurrences have been too small or poor to allow of mining and milling at a profit, the rich and extensive gold-bearing veins found within the last few years in northern Ontario show that all the gold prospects in the country are not "Will-o-the-wisps" which exist only for the purpose of enticing eager and unwary investors to destruction.

In the present paper the author attempts to give a brief outline of the character of the mineral veins in the pre-Cambrian rocks of central and northern Canada in which gold has been found; the modes of occurrence of gold in these veins, and the character of the rocks which form their walls, or which are sufficiently near to suggest some genetic relationship between them.

A New Myxobacterium: J. H. FAULL, Ph.D., F.R.S.C.

The microorganisms of this form heap up, organizing a stalked, branched or unbranched, one to several-headed fruiting body. On the heads columnar or conical cysts develop, on the surfaces of which a membrane is secreted. From these cysts, the bacteria later migrate into the main body of the head, the husks of the cysts persisting as shrivelled and twisted curls. The species exhibits a remarkable variability in respect to the morphological features of its fruiting bodies. It stands out as one of the most highly specialized of the order to which it belongs.

Some Anatomical Features of Willow Galls and their Significance: A. COSENS, M.A., Ph.D., and T. SINCLAIR, M.A. Presented by J. H. FAULL, Ph.D., F.R.S.C.

A study of the anatomy of certain willow galls led to the discovery of a well-defined aeriferous tissue which is not present in the corresponding regions of normal plants. A search for this tissue in normal plants led to its discovery in primitive areas or "vestige-carriers." Various experiments were made with negative results, to see if this tissue could not be induced by changing the environment. The conclusions reached are: (1) that

this is a primitive tissue in the willows and not a modification of the normal tissues due to changed environment; (2) that the reinstatement, under stimulus of vestigial characteristics in a plant has an important bearing on the question of gall production, for the gall producer not only exercises directive control over the active characteristics of the protoplasm, but over dormant as well. Under these conditions, unexpected structures and unusual combinations may well be produced.

On a Pre-Cambrian Outlier in Central Manitoba: Professor R. C. Wallace. Presented by A. H. Reginald Buller, D.Sc., F.R.S.C.

The Swarming of Ondotosyllis: C. McLean Fraser, Ph.D. Presented by A. B. Macallum, Ph.D., F.R.S.C.

Bibliography of Canadian Botany for the Year 1914: Dr. A. H. MacKay, F.R.S.C.

Bibliography of Canadian Geology for 1914: Wyatt Malcolm. Presented by R. G. McConnell, B.A., F.R.S.C.

Bibliography of Canadian Entomology for the Year 1914: Rev. C. J. S. Bethune, D.C.L., F.R.S.C.

Bibliography of Canadian Zoology for the Year 1914 (Exclusive of Entomology): E. M. Walker, B.A., M.B.

Henri M. Ami

SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

The twenty-second summer meeting of the society was held at the University of California on Tuesday and at Stanford University on Wednesday, August 3–4, 1915, in connection with the Panama-Pacific International Exposition, thirty-four members being in attendance. Professor M. W. Haskell, chairman of the San Francisco section, presided on Tuesday afternoon, and Professor R. E. Allardice at that on Wednesday afternoon.

Tuesday morning was devoted to a joint session with the American Astronomical Society and Section A of the American Association for the Advancement of Science. Addresses were delivered by Professors C. J. Keyser on "The human significance of mathematics," and G. E. Hale on "The work of a modern observatory." The astronomers, mathematicians and physicists lunched at the Faculty Club as guests of Professors Leuschner, Haskell and E. P. Lewis.

The social program included a dinner with the American Astronomical Society at the Hotel Oakland on Wednesday evening, an excursion to the Lick Observatory on Friday, and a luncheon given by Mrs. Phoebe Hearst at the Hacienda del Pozo de Verona on Saturday.

The following papers were read at this meeting:

L. E. Dickson: "Invariantive classification of pairs of conics modulo 2."

C. J. de la Vallée Poussin: "Sur l'intégrale de Lebesgue."

A. R. Schweitzer: "On the solution of a class of functional equations."

Nathan Altshiller: "On the circles of Apollonius."

Dunham Jackson: "Proof of a theorem of Haskins."

W. W. Küstermann: "Fourier constants of functions of two variables."

B. A. Bernstein: "A set of four independent postulates for the logic of classes."

G. A. Miller: "Limits of the degree of transitivity of substitution groups."

R. D. Carmichael: "On the representation of numbers in the form $x^3 + y^3 + z^3 - 3xyz$."

H. S. White: "Seven points on a gauche cubic curve."

M. W. Haskell: "The del Pezzo quintic curve."

L. J. Richardson: "A phase of Roman mathematics."

C. A. Fischer: "Functions of surfaces with exceptional points or curves."

A. R. Williams: "On a birational transformation connected with a pencil of cubics."

F. N. Cole: "Note on the triad systems in 15 letters."

A. B. Coble: "The determination of the lines on a cubic surface."

H. S. Vandiver: "An aspect of the linear congruence, with applications to the theory of Fermat's quotient."

C. H. Forsyth: "An interpolation formula based upon central and multiple differences."

G. M. Green: "On isothermally conjugate nets of space curves."

L. P. Eisenhart: "Surfaces of rolling and transformations of Ribaucour."

A. R. Schweitzer: "Generalized quasi-transitive functional relations."

L. M. Hoskins: "'Quantity of matter' in dynamics."

A. A. Bennett: "The iteration of functions of one variable."

The next meeting of the society will be held in New York, on October 30.

F. N. Cole,
Secretary